

Peer-Led Team Learning as an Instructional Strategy for Secondary School Science

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Abstract

This study investigated the impact of an instructional learning strategy, peer-led team learning (PLTL), on secondary school students' conceptual understanding of biology concepts related to the topic of evolution. Using a mixed methods approach, data were gathered quantitatively through pre/posttesting using a repeated measures design and qualitatively through observations, questionnaires, and interviews. A repeated measures design was implemented to explore the impact of PLTL on students' understanding of concepts related to evolution and students' attitudes towards PLTL implementation. Results from quantitative data comparing pre/posttesting were not able to be compared through inferential statistics as a result of inconsistencies in the data due to a small sample size and design limitations; however, qualitative data identified positive attitudes towards the implementation of PLTL, with students reporting gains in conceptual understanding, academic achievement, and interdependent work ethic. Implications of these findings for learning, teaching, and the educational literature include understanding of student attitudes towards PLTL and insight into the role PLTL plays in improving conceptual understanding of biology concepts. Strategies are suggested to continue further research in the area of PLTL.

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Table of Contents

	Page
Abstract.....	ii
Acknowledgements	iii
List of Tables	vi
List of Figures.....	vii
 CHAPTER ONE: INTRODUCTION TO THE STUDY	 1
Background of the Problem: Current Science Education Trends	3
Scientific Literacy and Conceptual Understanding.....	4
Scientific Literacy and Peer-Led Team Learning	6
Statement of the Problem Context	7
Purpose of the Study	9
Research Questions.....	10
Significance of the Study	10
Students, Schools, Science Education.....	10
Theoretical Framework.....	11
Scope and Limitations of the Study	11
Outline of Remainder of the Document	12
 CHAPTER TWO: REVIEW OF RELATED LITERATURE	 14
Vygotsky’s Learning Theory	14
Prior Knowledge	15
Conceptual Understanding	16
Conceptual Understanding and Scientific Literacy.....	18
Peer-Led Team Learning (PLTL)	22
Discussing, Questioning, and Applying Knowledge	23
Current Literature on PLTL	29
Conclusion.....	38
 CHAPTER THREE: METHODOLOGY AND RESEARCH DESIGN.....	 39
Research Methodology and Design.....	39
Selection of the Site and Participants	45
Participants	46
Instrumentation.....	47
Research Design.....	52
Data Collecting and Recording	57
Data Processing and Analysis	60
Methodological Assumptions.....	63
Limitations	63
Ethical Considerations.....	66
Restatement of the Area of Study	67

CHAPTER FOUR: PRESENTATION OF RESULTS	68
Research Question 1	68
Research Question 2	71
Interview Responses	75
CHAPTER FIVE: SUMMARY, DISCUSSION, AND IMPLICATIONS	85
Review of the Study	85
Discussion	89
Student Attitudes and PLTL	93
Implications	99
Considerations for Future Research	102
Conclusions	105
References	107
Appendix A: Brock Research Ethics Board Clearance	113
Appendix B: History/Attitude Questionnaire Towards Science	114
Appendix C: History of Evolution Test	115
Appendix D: Patterns of Selection Test	117
Appendix E: Speciation Test	119
Appendix F: Hardy-Weinberg Test	121
Appendix G: Peer-Led Team Learning Questionnaire	123
Appendix H: Interview Questions	124
Appendix I: Observation Protocol	125
Appendix J: Example Questions Peer-Led Team Learning Sessions	126

List of Tables

Table	Page
1: Repeated Measures Design.....	62
2: Paired Sample Statistics	70
3: Attitude Questionnaire Responses	73
4: Qualitative Themes	76

List of Figures

Figure	Page
1: A Graphic Illustration of Hodson's Perspective of Scientific Literacy.....	19
2: Aspects of Peer-Led Team Learning.....	24
3: Conceptual Understanding	40

CHAPTER ONE: INTRODUCTION TO THE STUDY

The purpose of this study was to investigate the effect of implementing a learning strategy—peer-led team learning (PLTL)—on secondary school students' conceptual understanding of science using a mixed methods approach. Throughout recent decades, education in North America has been characterized by a shift from teacher-centred learning pedagogies to student-centred practices (Hodson, 2003; Osborne, 2002; Venville, & Dawson, 2010). In science education, this shift has been influenced by constructivist perspectives of learning presented in the works of Dewey (1940), Piaget (1952), and Vygotsky (1978) that place the student at the centre of learning. Following the current trends of student-centred learning, this research involved the implementation of a student-centred learning strategy known as PLTL.

PLTL was originally developed for undergraduate science courses (in the USA) to enhance learning of science through small instructional groups led by students' peers (known as peer-leads). It had been established within universities as a potential replacement for tutorial sessions and is characterised by upper year students answering questions pertaining to lectures with their undergraduate peers in small groups. The benefits outlined in the literature review (Chapter Two) of PLTL for student understanding at the undergraduate level include students having significantly higher grades and finding the learning strategy to be socially engaging and intellectually stimulating (Micari, Streitwieser, & Light, 2006; Tessier, 2007; Tien, Roth, & Kampmier, 2002). While there have been investigations of peer tutoring (Cheung, & Winter, 1999; Colvin, 2007; Topping, 2005), small group peer teaching (Tessier), and co-operative learning (Acar & Tarhan, 2008) at the postsecondary school level, there is a lack of

research on the impact of PLTL within secondary school science classes. Hence, the current study adapted the PLTL format used in undergraduate science classes to a secondary school biology classroom and investigated its effect on students' conceptual understanding of scientific concepts related to evolution.

Conceptual understanding requires the learner to go beyond rote memorization, recall of facts, and paraphrasing of information (Nieswandt, 2007). Prior experiences as a private tutor allowed me to develop perspectives on students' conceptual understanding of scientific concepts. As a private tutor, I observed and interacted with students who said they understood scientific concepts they were studying. Despite believing that they understood concepts, students would have difficulties during testing which was evidenced in their grades and their apprehensions voiced in communicating an understanding of the concept. My role as a tutor was to help students go beyond a superficial level of understanding to deeper levels of cognition.

Conceptual understanding requires a higher level of thinking. According to Nieswandt (2007), conceptual understanding involves demonstrating "the ability to recognize new information as something different from one's current understanding and beliefs, to identify inconsistencies, and to construct explanations to reconcile knowledge conflicts, or to seek connections among diverse pieces of information" (p. 909). Additionally, conceptual understanding includes cognitive processes such as summarizing, explaining new concepts, and applying the newly learned information in unfamiliar contexts, including everyday life phenomena (Anderson & Krathwohl, 2001). PLTL provides opportunities for students to engage in higher level cognitive processes. It specifically involves students consolidating information presented in lecture style through

collaboratively discussing, questioning, and applying what was learned in small groups, facilitated by a peer-lead (Quitadamo, Brahler, & Crouch, 2009). In terms of the current study, a peer-lead is a student who facilitates the learning process within the small group setting and is considered a guide or mentor (Micari et al., 2006; Tien et al., 2002).

The goal of implementing this learning strategy was to have students inquire on deeper levels, promoting meaning and relevancy of topics learned in class. Secondary school students are faced with understanding challenging scientific concepts. Providing them with the opportunity to participate in a learning strategy such as PLTL may enhance conceptual understanding of these topics. Consequently, the current research investigated whether findings of previous PLTL studies would be similar to findings of the secondary school science study, particularly pertaining to increased understanding of the topic.

The subsequent sections discuss the following: (a) background of the problem, (b) statement of the problem context, (c) purpose of the study, (d) significance of the study, (e) theoretical framework, and (f) limitations of the study.

Background of the Problem: Current Science Education Trends

While working as a private tutor, I found that some secondary school students considered science to be one of the more challenging subjects due to its sometimes abstract content. Many of the students could define scientific terms, but when it came to explaining these concepts and applying them in different ways, they had difficulty applying their knowledge in these situations. As a result, some students learned the content; however, not in a way which exhibited conceptual understanding, but rather superficial learning. Venville and Dawson (2010) identify this, stating, “Unfortunately

many students memorize what they learn in school as isolated facts and never make the important leap to well-connected, fruitful knowledge” (p. 955).

Defining terms, identifying, and outlining topics, is the most basic level of learning. In order for students to develop conceptual understanding they must go beyond rote memorization of terms and make connections among ideas, concepts, and topics in a variety of contexts (Eberlein et al., 2008).

Scientific Literacy and Conceptual Understanding

Studies done by Schmidt, McKnight, Cogan, Jackwerth, and Hoang (1999) and Tobias (1990-as cited in Olson & Mokhtari, 2010) indicate that:

Science instruction that focuses on memorizing vocabulary and using formulas to solve many identically structured problems is associated with a lack of conceptual understanding of science, an inability to use science process skills, and a decreased interest in pursuing science related activities and careers. (p. 57)

Developing conceptual understanding requires going beyond facts and figures and learning to explore information in ways which promote higher levels of cognition. Current research suggests that problem-based learning, inquiry, discussion, and developing questioning techniques all play an integral role in furthering conceptual understanding (Duschl, 2008). Developing learners who can analyze, interpret, and make connections among scientific concepts also lays the foundation for developing a society of scientifically literate individuals.

Holbrook and Rannikmae (2009) succinctly summarize current notions of scientific literacy:

The trend in defining scientific literacy is suggested as away from the short term product approach, in which the facts and skills are paramount, towards the inclusion of issue-based teaching, the need to go beyond scientific problem solving to encompass socioscientific decision making, and the recognition that scientific literacy relates to enabling citizens to effectively participate in the real world. (p. 279)

Scientific literacy aims to shift the context of science learning from being focused on abstract facts towards integrating meaningful contexts that relate to everyday situations (Roth & Barton, 2004). Scientific literacy addresses the issue of science being not only important for future scientists but also for each student. Murcia (2009) articulates this best by stating, “science education cannot focus solely on the preparation of students for higher level studies [in the sciences] or the preparation of future scientists” (p. 215). Science education should be a well-rounded approach to understanding the world around us through scientific investigation (Murcia). Scientific literacy then is combining the understanding of the “products and processes of science . . . [in] situations that students are likely to encounter as citizens” (Roberts, 2007, p. 730).

The Ontario science curriculum supports the development of scientific literacy in the class through recommending the practice of strategies that develop four categories of knowledge and skills: (a) knowledge and understanding of scientific content, (b) thinking and investigation skills and strategies (e.g., formulating questions, problem-solving), (c) communication of ideas and information, and (d) application of knowledge and skills in a variety of contexts (Ontario Ministry of Education, 2008). The second, third, and fourth categories connect strongly to conceptual understanding, promoting learning that goes

beyond rote memorization and into higher levels of cognition through asking questions, discussion, and application of scientific concepts to new contexts (Quitadamo et al., 2009), which also supports the development of scientifically literate individuals (Duschl, 2008).

Scientific Literacy and Peer-Led Team Learning

Scientific literacy has been defined and understood from different perspectives. Hodson (1998) views scientific literacy in terms of three characteristics: learning science, learning about science, and doing science, a view that will be elaborated on in Chapter Two and used as the basis for understanding scientific literacy in this study. These three characteristics: learning science, learning about science, and doing science are “the new perspective of science education [which] focuses on what students need to do to learn science” (Duschl, 2008, p. 269). Each characteristic involves the students acquiring, developing, or engaging in science learning by using their prior knowledge to develop a meaningful understanding of the science phenomenon being studied. Strategies utilized in PLTL advance some of the characteristics of scientific literacy. For example, students use their prior knowledge to discuss, question, and learn about science applications in a variety of contexts.

Current research suggests that students should play an active role in developing an understanding of concepts being studied through constructing their own knowledge (Venville & Dawson, 2010). PLTL helps students to be accountable for their own learning through developing an interdependent work ethic, prompting students to explain their understanding, and emphasizing active engagement (Tien et al., 2002). Hence, students play a major role in developing their own understanding of concepts by

collaborating with peers and using their own words to articulate and construct explanations. Learning strategies promoting differentiated instruction, like PLTL, have been advocated for developing conceptual understanding (Alao & Gutherie, 1999).

Moving science learning from memorizing facts and rote learning towards using prior knowledge, collaborating, discussing, questioning, and applying science learning may lead to cultivating a culture of learners who are able to learn science, learn about science, and do science.

Statement of the Problem Context

In preparation for my thesis I participated in an internship in 2009 at the same secondary school where the current research took place. During the internship, different grade level science classes were observed to gain knowledge of the breadth of current instructional strategies. At that secondary school, typical classroom instruction included: overhead, PowerPoint, and blackboard notes, laboratories, textbook work, and class discussions. As a result of these experiences, it was noted that instructional strategies that were student centred were not often implemented in the classroom. Roth and Barton (2004) state similar conclusions,

Science in school remains virtually unchanged; students are confronted with basic facts and theories . . . science class has become a mechanism for controlling what it means to “know and do science” rather than an empowerment zone where students are valued for their abilities to contribute to, critique, and partake in a just society. (p. 5)

Despite observations of a lack of student-centred instruction, current science education literature emphasizes that students need to be active participants in their learning (Hodson, 2003; Murcia, 2009; Osborne, 2002; Venville & Dawson, 2010).

Current education trends are moving away from a teacher-centred set-up and towards learning that focuses less on direct instruction and more on active learning and implementing strategies which may facilitate this (Hodson, 2003). In order to continue to move towards student-centred instruction, more opportunities need to be provided for students to actively engage in their own learning.

Incorporating learner-centred instructional methods as part of regular teaching would give students the opportunity to focus on the topic. PLTL is a student-centred instructional strategy which may provide opportunities for students to increase their conceptual understanding by thinking about the topic on a deeper level in peer-led groups. Through collaboratively discussing, questioning, and applying what was learned, students may think differently about what they learn and how it affects them and the world around them. Gaining additional perspectives through collaboratively working with classmates provides student-centred reinforced learning and opportunities to enhance scientific literacy.

Whether or not students continue to postsecondary school sciences does not negate the need for a society of individuals who are able to discuss and question scientific literature, media, and advances made in science presented daily. Developing scientifically literate individuals may advance upcoming generations in their ability to communicate about science presented in media and other aspects of daily life. Regardless of students' academic ambitions and their level of science (whether it is advanced or not), being

scientifically literate provides them with a solid foundation to assess the validity and reliability of science issues in the media and in their everyday lives.

According to the Ontario science curriculum (Ontario Ministry of Education, 2007), “people who are scientifically literate can find or determine answers to questions about everyday experiences . . . they are able to describe, explain, and predict natural phenomena” (p. 163). Developing scientific literacy requires students to “learn and apply their knowledge and skills effectively . . . develop[ing] a solid understanding of scientific concepts” (p. 32). PLTL has been shown through studies done by Micari et al. (2006) and Tien et al. (2002) to facilitate continued collaborative group efforts to discuss and question what is being learned, supporting the application of information to unfamiliar contexts, including everyday life phenomena.

Focusing education on student-centred learning, through implementing learning strategies like PLTL, supplements current curricular practices and provides opportunities to develop conceptual understanding, contributing to scientific literacy.

Purpose of the Study

The purpose of this study was to investigate the effect of the peer-led team learning (PLTL) strategy on students’ conceptual understanding of biology concepts and explore students’ attitudes towards the PLTL strategy. The goal was to have secondary school students engage on a deeper level with the topic *evolution* as they explored (a) the history of evolution, (b) patterns of selection, (c) speciation, and (d) Hardy-Weinberg principles, through collaborative group discussion and reflection on questions related to the topics.

Research Questions

The study addressed the following questions:

1. What impact does the PLTL instructional strategy have on grade 11 students' conceptual understanding of biology concepts related to the topic of evolution?
2. What are students' attitudes towards the PLTL instructional strategy?

Question 1 was investigated by having students write a pretest, participate in traditional teacher instruction, followed by a PLTL session or a non-PLTL session. Students then wrote the same test as a posttest. Question 2 was explored by students completing a questionnaire and participating in individual interviews.

Significance of the Study

The findings of this study are expected to be beneficial to students, teachers, and school boards and contribute to the science education literature/research. Opportunities for students to engage in learner-centred activities may improve their conceptual understanding and scientific literacy and may contribute to their participation in postsecondary science fields.

Students, Schools, Science Education

PLTL sessions potentially provide students with the opportunity to enhance conceptual understanding. Discussing scientific content with their peers and utilizing scientific terminology creates the framework for developing increased understanding of biology concepts.

The study should provide educators with an indication of the influence of PLTL on promoting conceptual understanding. Teachers may gain insights into alternative teaching strategies that work to build life skills in addition to scientific understanding.

Furthermore, it is hopeful that the implications of this study will contribute to literature on the impact of PLTL in science education. Researchers could benefit by gaining an increased understanding of the role PLTL can play in the classroom and in students' learning.

Theoretical Framework

Peer-led team learning is based on the premise of learning through experience, interacting with one's environment, in this case other students, in order to generate meaningful learning experiences. The theoretical framework was developed through gaining an understanding of conceptual understanding and its implications for learning.

Chapter Two will provide an in-depth analysis of conceptual understanding, detailing previous definitions and how it pertains to the current study as well as further incorporating the role of conceptual understanding as it pertains to promoting scientific literacy. Additionally, the concept of PLTL was built on constructivist theories, in particular Vygotsky's theory of the zone of proximal development. The relationship among conceptual understanding, PLTL, and Vygotsky will be explored in Chapter Two. Developing an understanding of the aforementioned creates the framework for the design and conduct of the research.

Scope and Limitations of the Study

This study was a small project, providing the framework for further studies based on the results. It was arranged on a small scope in order to identify whether or not meaningful data would be presented. As a result, there were a number of limitations to the study's scope and generalizability.

The scope of the study was small, being limited to one classroom in one secondary school within an urban community. No randomization was done in order to select the above, resulting in a group of students and a teacher who may or may not have been representative of the general population. The makeup of students may not equally represent proportions of males and females. Equally important, due to the unrepresented nature of the classroom, a control group for comparison would have benefited the study. However, due to limited resources, additional classes with a makeup similar to the class involved were not included.

The parameters of the study limit the generalizability. Results cannot be generalized to the general population; however, based on results, future research can be implemented to address the current issues in this study. Despite some of the drawbacks listed, this study, although rather limited, produced results that may allow researchers to identify how PLTL can be implemented and its effect on students. Greater details regarding the limitations of the study are discussed in Chapter Three, Methodology and Research Design.

Outline of Remainder of the Document

The following section outlines the format for the remaining chapters including brief descriptions of topics covered in subsequent chapters.

Chapter Two begins by reviewing in detail what conceptual understanding is, specifically looking at previous definitions from the literature and how they are integrated with scientific literacy. Following this description of conceptual understanding, a formal definition of PLTL is expanded on, and empirical studies involving PLTL are reviewed. PLTL mainly focused on three aspects: (a) collaborative small group communication, (b)

asking questions, and (c) applying knowledge, which are discussed. Additionally, similarities and differences between past studies and the current study are addressed.

Chapter Three is the methodology and research design section. As such, the chapter reviews the research methodology and design, which includes selection of site and participants in the study. Furthermore, the qualitative and quantitative aspects of the study pertaining to the reasoning for mixed methods and how the two methods of data collection were integrated in the study are discussed. The chapter concludes by addressing limitations, ethical considerations, and establishing validity and credibility.

Chapter Four presents the results. Analysis of quantitative data using SPSS is presented. Details of the statistical tests conducted are reported. In addition, results from the questionnaire and interviews are thematically organized, with each data set supporting the other.

Chapter Five is the summary/conclusions of the study. The chapter begins with a brief synopsis of the research. Following the synopsis, the discussion section expands on and explains the findings and provides implications of the results. The chapter ends with recommendations to future researchers in the area.

CHAPTER TWO: REVIEW OF RELATED LITERATURE

The purpose of this study was to investigate the effect of implementing PLTL on students' conceptual understanding of evolution concepts and students' attitudes towards PLTL. Hence, Chapter Two reviews the basis of PLTL and its constructivist roots through briefly discussing the ideas of Vygotsky. Thereafter, current definitions of conceptual understanding, the importance of its development within the current school system, as well as how it pertains to scientific literacy are discussed. In relation to conceptual understanding, PLTL is defined using a culmination of ideas from previous studies. Additionally, three specific attributes: (a) discussing, (b) questioning, and (c) applying are discussed in order to gain a broader understanding of PLTL. Concluding sections of the chapter include reviewing and critiquing the current literature on PLTL.

Vygotsky's Learning Theory

Vygotsky's theories on learning played a role in the development of this study. Vygotsky (1978) detailed the importance of collaborative learning and the positive effects resulting in cognitive growth. He suggested that higher levels of thinking require collaboration. In order to develop these higher levels, Vygotsky claimed that collaboration with other learners may guide the learner in reaching higher levels of cognition that would not be possible without working with more capable peers. His learning theory is developed as a two-stage process consisting of two developmental levels.

The first developmental level Vygotsky (1978) denoted as the "actual developmental level, that is, the level of development of a child's mental functions that has been established as a result of certain already completed development cycles" (p. 85).

The actual developmental level is cognitive growth that occurs as a result of previous experiences, as in prior knowledge. The second developmental level Vygotsky refers to as the zone of proximal development, which “is the distance between the actual development as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or collaboration with more capable peers” (p. 86).

According to Vygotsky, knowledge acquisition and higher levels of cognition can be furthered through collaborative efforts, working with others who give additional insight into understanding concepts that may be just beyond the scope of the learner. Cognitive growth is enhanced by utilizing resources outside oneself, resulting in a process of maturation and prospective development. Thinking occurs as a result of transforming one’s thought processes by working with others to generate ideas that are beyond one’s actual developmental level into the zone of proximal development. PLTL provides students with opportunities to learn from more capable peers and to collaborate among themselves to learn a task that may be beyond their individual capabilities.

Prior Knowledge

Prior knowledge is an integral part of the actual development level proposed by Vygotsky, and it plays a role in the development of conceptual understanding. According to Alao and Guthrie (1999), “[the] acquisition of conceptual understanding is influenced by prior knowledge” (p. 244). This is consistent with Vygotsky’s view that prior knowledge (especially knowledge of prior concepts) is foundational for learning new scientific concepts. Prior knowledge, also referred to as domain knowledge (O’Reilly & McNamara, 2007), gives students the opportunity to use their knowledge base to come to

an understanding of the topic. Prior knowledge can also include knowledge gained from everyday experiences (Bell & Freyberg, 1985). As students draw on their domain knowledge, their conceptual understanding is facilitated “by enhancing students’ abilities to (a) assimilate and integrate new information and (b) distinguish relevant from irrelevant information” (O’Reilly & McNamara, p. 244). Conceptual understanding involves the intersection between new and old knowledge, incorporating the two to synthesize an understanding in greater depth.

Conceptual Understanding

In order to further develop the structure of the study, conceptual understanding must be defined. Conceptual understanding has been defined by a number of authors. Nieswandt (2007) defines it in terms of creating meaningful connections; Alao and Guthrie (1999) present the definition in terms of understanding the breadth and depth of concepts; and Anderson and Krathwohl (2001) describe the cognitive processes involved in conceptual understanding.

Conceptual understanding, according to Nieswandt (2007), involves “seeking connections among various pieces of information, or applying the newly learned information to everyday life phenomenon” (p. 909). Students who are able to conceptually understand the scientific concept demonstrate “the ability to recognize new information as something different from one’s current understanding and beliefs, to identify inconsistencies, and to construct explanations to reconcile knowledge conflicts, or to seek connections among diverse pieces of information” (p. 909). Hence, conceptual understanding entails moving beyond the information presented in class in order to develop a personal understanding of the topic. Developing connections, constructing

explanations, and identifying inconsistencies are cognitive processes a student must experience in order to move beyond rote memorization to conceptual understanding of the topic.

Furthermore, Alao and Gutherie (1999) characterize conceptual understanding by breadth and depth. As such, they describe the first part of conceptual understanding as the breadth “[that] refers to the extent that knowledge is distributed and represents the major sectors of a specific domain” (p. 244). The student who demonstrates the breadth of knowledge is able to define terms and has a general understanding of the meaning of the terms. Depth is the second portion of conceptual understanding which “refers to the knowledge of scientific principles that describes the relationship among concepts” (p. 244). Students demonstrating conceptual understanding at this level are able to construct meaning through using the knowledge of other relationships, illustrating their ability to explain interactions. Conceptual understanding then is the point at which students utilize previously learned information to construct cognitively enhanced representations of the same concept.

Anderson and Krathwohl (2001) discuss the cognitive processes involved in learning, (a) understanding and (b) applying. According to Anderson and Krathwohl, understanding is “construct[ing] meaning from instructional messages, including oral, written, and graphic communication” (p. 31), whereas applying is “carry[ing] out or us[ing] a procedure in a give[n] situation” (p. 31). Hence, conceptual understanding at this cognitive level involves understanding information being presented in addition to applying that information in a particular situation.

Students demonstrating conceptual understanding are not only able to identify and label terms, they are also able to construct and expand on explanations of concepts in the topic given and apply that knowledge in a new situation, including everyday life contexts.

Conceptual Understanding and Scientific Literacy

Becoming scientifically literate includes developing an understanding of scientific concepts through questioning everyday experiences of natural phenomena in order to explain, describe, and predict (National Science Education Standards, 1996). Hodson (1998) offers a comprehensive perspective on scientific literacy. He characterizes scientific literacy as:

1. Learning science – acquiring and developing conceptual and theoretical knowledge.
2. Learning about science – developing an understanding of the nature and methods of science, an appreciation of its history and development, and an awareness of the complex interactions among science, technology, society, and environment.
3. Doing science – engaging in and developing expertise in scientific inquiry and problem solving. (p. 5)

Figure 1 shows a graphic illustration of the aspects involved in becoming scientifically literate as it relates to Hodson's definition. All three aspects work in tandem to develop a scientifically literate student. Developing conceptual understanding ties in more with "learning science" and with the application interactions associated with "learning about science" in Hodson's framework. The important question to consider then is: How are

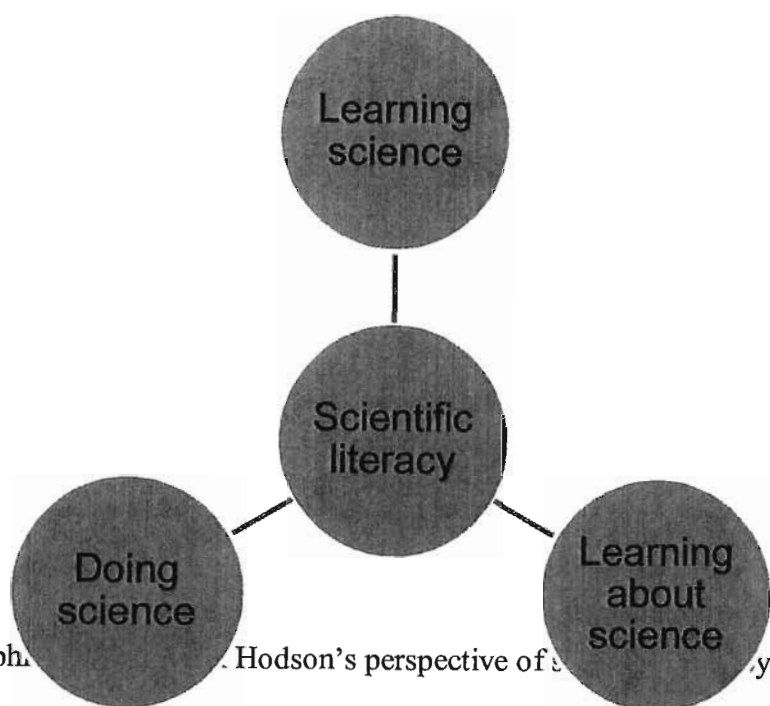


Figure 1. A graph of Hodson's perspective of science education.

these characteristics of scientific literacy (which include conceptual understanding) developed in the classroom?

Developing scientific literacy may be accomplished through diversifying instructional strategies in the classroom (Hodson, 2003). PLTL is one such strategy which could be introduced to further diversify instruction for students. Developing conceptual understanding in students through a student-centred learning strategy like PLTL promotes the skill sets of communicating, such as discussing scientific concepts at a deeper level. Communication skills are a key component of scientific literacy. In order for students to develop conceptual understanding and become scientifically literate, students need to be able to have scientific discussions using the appropriate vocabulary as a part of relating science to everyday life (Roth & Barton, 2004). Becoming scientifically literate requires that students understand scientific relationships and appropriate use of the language (Westby & Torres-Velasquez, 2000). Furthermore, Osborne (2002) articulates:

Thus, if we wish students to gain insights and understanding of the manner and nature of scientific reasoning, we must offer to them the opportunity to use and explore that language, i.e., to read science, to discuss the meaning of its text, to argue how ideas are supported by evidence and to write and communicate the language of science. (p. 204)

Osborne highlights three communication features: (a) reading, (b) discussing, and (c) arguing that typify the type of communication that can occur in PLTL groups (PLTL is explained in detail in the next subsection). PLTL provides opportunities for students to delve deeper into the topic of study through communicating with their peers,

collaboratively discussing, asking questions, and working towards an understanding of the topic. This active cognitive engagement in the topic supports developing a personal relevancy as a part of advancing conceptual understanding. The communication skills used in PLTL sessions also support the development of scientific literacy.

How can conceptual understanding be conceptualized in relation to scientific literacy? Mintzes and Wandersee (1998) and Scott et al. (2007-as cited in Venville & Dawson, 2010) purport that

for students to have conceptual understanding, as opposed to memorized facts, the material being learned must make sense to the learner in terms of their [*sic*] existing knowledge and they must voluntarily choose to incorporate the new knowledge in a logical, integrated manner. (p. 955)

In terms of relating this to the development of scientific literacy, one interpretation is that students must first develop a basic understanding of the science content and then build up their knowledge base in order to understand the effects of science and technology on society (Flower, 2000). Working from a solid foundation of conceptual understanding of the science topic, students can then move on to evaluating their understanding of the concept as it relates to science in the environment or the media.

Scientific literacy stresses the value of being able to critically assess scientific content. This higher level of cognitive development must stem from a thorough understanding of the scientific content being considered, which may lay the foundation for “be[ing] able to evaluate the quality of scientific information on the basis of its source and the methods used to generate it” (National Science Education Standards, 1996, p. 22). Student-centred learning strategies like PLTL can act as the foundation for

developing conceptual understanding and contribute to the development of scientific literacy.

Peer-Led Team Learning (PLTL)

There are many interchangeable names for PLTL such as small group peer teaching (SGPT; Tessier, 2007), peer tutoring (Colvin, 2007), and peer teaching (Ramaswamy, Harris, & Tschirner, 2001), all of which include the broad premise of peers teaching peers. Topping (2005) gives a definition of peer learning as

the acquisition of knowledge and skill through the active helping and among status equal or matched companions. It involves people from similar social groupings who are not professional teachers helping each other to learn and learning themselves by doing. (p. 631)

Peer learning is essentially peers teaching each other and gaining an enriching learning experience through that. PLTL further emphasizes the importance of peers leading sessions in order to facilitate small group conversations on the current topic of study. Through the implementation of PLTL, the hope is that students would increase their conceptual understanding as evidenced through a written assessment. Student “assessment must evaluate conceptual understanding over rote memorization” as students need to demonstrate “what they know by processing and evaluating information . . . explain[ing] what they know clearly and in complete sentences” (Eberlein et al., 2008, p. 269). Consequently, allowing students to display their knowledge through written assessments is considered an accepted way of providing teachers with insight into student understanding. This is also used as a means to further scientific literacy, “as knowing and understanding both some of the content and the appropriate use of language of science is

an essential component on the path towards scientific literacy” (Osborne, 2002, p. 214) which can be expressed through students constructing meaningful sentences (Osborne).

Discussing, Questioning, and Applying Knowledge

PLTL incorporates three aspects: (a) discussing, (b) questioning, and (c) applying (Quitadamo et al., 2009), all of which are done collaboratively in small groups (see Figure 2). Developing a greater understanding of PLTL requires expanding on these three aspects.

Discussing

Gaining knowledge through discussions is different than attempting to construct knowledge through listening to someone. Discussions require the active participation of more than one party; discussing information involves thinking, questioning, and learning on a level that is not possible through just listening to someone talk. Shared experiences generate ideas and growth only possible through interaction with others (Vygotsky, 1978). Implementing learning strategies such as PLTL allows students to discuss a topic of study, thus actively engaging the learner. McCrone’s study (as cited in Weber, Maher, Powell, & Stohl, 2008) stated, “discussions allow[ed] students to test ideas, to hear and incorporate the ideas of others, to consolidate their thinking by putting their ideas into words, and hence, to build a deeper understanding of key concepts” (p. 247). When students share ideas with each other, cognitive growth occurs as a result of discussions on topics at a deeper level.

Thus, discussion is an important component of PLTL, giving students the opportunity to bring forth ideas they may not have thought about until given the chance to communicate in small groups (Tien et al., 2002). Conceptual understanding develops

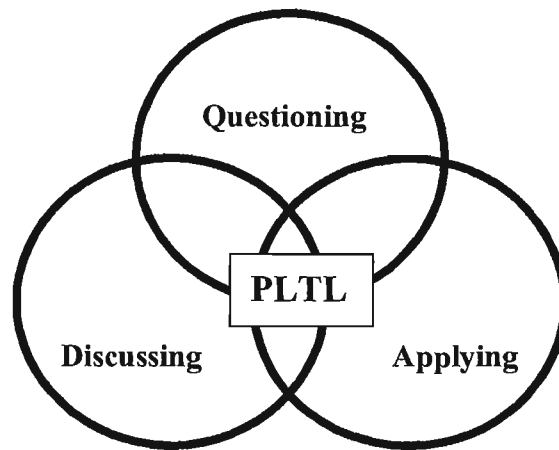


Figure 2. Aspects of peer-led team learning.

as a result of using prior knowledge, sharing that knowledge, and in return gaining new knowledge through small group discussions. Students often gain a superficial understanding of content through listening to lectures. However, when learners become active participants in what they are learning, enriched meaning and understanding may result. Learners may also learn to think in a different way and in turn share knowledge in different ways with others.

Discussions also allow students to come to their own conclusions and ways of understanding a topic, thereby promoting the use of scientific vocabulary (Depaz & Moni, 2008; Hodson, 2003; Osborne, 2002). Developing scientific vocabulary in order to communicate effectively with others is a skill that promotes scientific literacy. At the same time, “communication skills are fundamental to the development of scientific literacy, and fostering students’ communication skills is an important part of the teacher’s role in the science curriculum” (Ontario Ministry of Education, 2008, p. 41). Developing communication skills for future social interactions and understanding of scientific and technological advancements is crucial for continued success within the 21st century for science learners.

Discussion in small groups may parallel how scientists communicate to construct knowledge. Scientists also take into account the significance of communication within their practice, as the following statement by Tien et al. (2002) suggests:

Empirical results are interpreted, and conclusions are reached through the process of conflict, discussion, and argument as ideas and models are refined and revised. In the classroom, conceptual understanding is dependent on the opportunity to socially construct, and reconstruct one’s own personal knowledge through a

process of dialogic argument. Understanding develops through the course of communicating ideas and interacting with others. (p. 608)

It is especially important within science to foster these skills. As Depaz and Moni (2008) state, “there is evidence to suggest that small group work within disciplines is a means to learning that reflect working as a professional scientist, to promote deep learning in science” (p. 1). Equally important is the possibility of the small group discussion generating and maintaining interest in the sciences for students preparing for possible careers as future scientists as well as for scientifically literate individuals. Also, sharing ideas is one of the many skills necessary to succeed in life. Discussions promote the development of such skills to enable effective communication with others.

Questioning

Questioning is an important developmental aspect that allows learners to ask questions in order to further understanding as a part of discussing. As students generate meaningful discussions, questioning should become a natural part of that process.

Questioning involves examining what was learned from an inquisitive angle. Students are able to question the meaning of what is learned, its significance, and how to apply what is learned outside the classroom. Findings from Rennie, Goodrum, and Hackling (2001) suggests that the ideal science education should promote scientific literacy through allowing students to question and investigate scientific matters. Deep understanding and application abilities develop when students are willing to take risks to ask meaningful questions to better grasp what is being taught. Furthermore Hodson (as cited in Hodson, 2003) “suggest[s] that developing an understanding of the ideas and concepts of science means that pupils spend more time interacting with ideas” (p. 213).

Interacting with ideas implies thinking more about what is being presented and as a result asking questions about what is being presented. As a part of PLTL, students take the information presented in lecture and question what is being taught to gain insight and develop conceptual understanding.

One of the aims of PLTL is to develop students' abilities to ask meaningful questions leading to deeper levels of understanding (Weber et al., 2008). As such, students should be "actively engaged in their own learning by having them find answers to questions and teach those answers instead of simply copying notes from a lecture" (Tessier, 2007, p. 68). Collaboratively asking questions and finding solutions allows for shared cognitive development, as the learners become primarily responsible for the own understanding of concepts and how to apply their understanding.

Applying

In addition to discussing and questioning, applying what has been learned is an equally important part of PLTL groups. Applying knowledge engages students on another level and is a means of helping them to discover personal relevancy or meaning from what is being taught (Castano, 2008). Connecting the abstract with something that is relevant may provide insight into a topic which may have seemed insignificant before.

In regards to scientific content, some topics can be abstract and difficult to grasp and/or relate to in order to make meaningful connections. Consequently, students may not be grasping information if they are simply copying scientific theory from a blackboard. Hodson (2003) states, "providing content in socially and personally relevant context . . . can provide the motivation that is absent from current abstract, de-contextualized approaches and can form a base for students to construct understanding that is personally

relevant, meaningful, and important” (p. 654). This requires that learning continue to move beyond the nonreciprocal method of teaching, since it is not the most effective method to induce understanding (Ramaswamy et al., 2001). Implementing strategies which develop collective thinking and making connections result in meaningful learning. Castano (2008) clearly articulates:

Connection of scientific concepts with the day to day life . . . has a positive impact in the understanding of scientific concepts. This impact seems to be further enhanced in an environment where students have the opportunity to discuss where the application of science implies making decisions that affect people and other living organisms. (p. 583)

Helping students to see the applications of science beyond the classroom plays an integral role in developing a deeper, more meaningful understanding of science and how it affects them and the world around them. Encouraging students to think of relevant applications beyond the scope of learning presented may enhance their conceptual understanding of scientific concepts.

In conclusion it can be said that PLTL actively integrates discussing, questioning, and applying information during regular classroom instruction within small groups. Students work collaboratively to process scientific concepts on a deeper level. As students engage in learning through discussing, questioning, and applying their understanding, they hopefully gain an increased conceptual understanding of the concepts.

Current Literature on PLTL

Peer-led team learning strategies have been actively integrated within a number of academic and nonacademic settings under various names. Some of its aliases are peer tutoring (Cheung & Winter, 1999; Colvin, 2007; Topping, 2005), class wide peer-tutoring (CWPT; Bond & Castagnera, 2006; Kamps et al., 2008), peer-assisted learning strategies (Lockspeiser, O' Sullivan, Teherani, & Muller, 2008), small group peer teaching (SGPT; Tessier, 2007), and peer teaching (PT; Depaz & Moni, 2008; Ramaswamy et al., 2001). They are all very similar, with slight variations in the presentation of the strategies. As such, the following section will review previously done studies which fall under the category of peer learning strategies.

Class Wide Peer-Tutoring

Class wide peer-tutoring (CWPT), stresses the importance of peer-tutoring, peers tutoring on a class wide basis, students being both the tutor and tutee, and reciprocal tutoring (Cheung & Winter, 1999). In the study done by Cheung and Winter, researchers looked at the implementation of CWPT with (+R) and without (-R) positive reinforcers such as praise and implementing a team points system. Male and female Chinese secondary school students, mean age 13, were administered pre- and posttests assessing their spelling skills and gauging their intrinsic interest in the course. Results showed significant gains in spelling ability for both groups, with even greater significant gains for the CWPT group with positive reinforcement. In regards to intrinsic interest, CWPT -R showed no difference between pre- and postassessments, whereas within the CWPT +R, student interest increased in the course. This study was completed under the premise that CWPT creates significant learning gains for students. Additionally, researchers

discovered that implementing CWPT with positive reinforcement further amplified students' academic achievement. Although the study did implement a peer teaching strategy, the goal of the research was to identify whether or not its effects (peer tutoring) could be amplified.

The exchange of information that occurred in this study was the result of each individual bringing forth knowledge into a situation and also gaining knowledge from other students, as tutors and tutees. Previous studies that have integrated these sessions were “designed to accelerate student learning by increasing students’ opportunities to respond and thereby increasing their level of academic responding” (Cheung & Winter, 1999, p. 192). Promoting discussions and questions are aspects of consolidating knowledge which these learning sessions developed. Findings showed that students felt confident and comfortable asking questions. Paralleling PLTL, CWPT aided students in increasing cognitive growth through interactive peer learning; students learned through questioning, teaching, and being taught by peers, resulting in increased understanding.

Peer-Led Team Learning Undergraduate Organic Chemistry

Researchers Tien et al. (2002) did an 8-year study, 1992–1994 ($n = 942$) and 1996–1999 ($n = 2,157$) on the implementation of PLTL for undergraduate students in first semester organic chemistry. The study compared student performance, retention rates (within the program), and attitudes of students participating in the PLTL workshops versus students in the traditional recitation sessions. Recitation sessions were the traditional means to aid organic chemistry students during the term. Graduate students guided reviews, answered questions, and looked at old exams. PLTL sessions were more student centred than recitation sessions; undergraduates facilitated the sessions, group

sizes were smaller, and students worked collaboratively to solve problems rather than just listening to instructions from graduate students (Tien et al., 2002).

In addition to comparing final grades, a questionnaire—gauging student interest and perception of the value of the sessions—was completed. As well, 40–60 minute interviews were done with peer-leaders to assess their views. The study included background aspects of the students to account for any prior knowledge that could allow some students to have a much greater advantage. Taking these variables into account, the study produced results that suggested that all students earned significantly higher grades in the PLTL group versus the recitation group. Students' responses on the questionnaires also verified that they felt the program helped them learn organic chemistry and was socially engaging, intellectually stimulating, and a productive use of time. The quantitative (comparing final grades) and qualitative (survey and interview) measures were analyzed via ANOVA and audio recordings respectively (Tien et al., 2002).

The 8-year study illustrated that students participating in PLTL sessions versus traditional recitation groups had an advantage. In their study, as students were approached by peers relatively close to their academic level (undergraduates), the interactions that occurred appeared to be more meaningful than traditional graduate taught recitation sessions (Tien et al., 2002).

Peer-Led Team Learning: Undergraduate Chemistry

Typically PLTL has taken place within postsecondary institutions. Hockings, DeAngelis, and Frey (2008) did a study of undergraduate chemistry students and the impact that PLTL had on their academic performance. In addition to looking at students'

grades, surveys were administered assessing attitudes and self-confidence. The goal of their study was to:

1. Teach undergraduates how to effectively use group study
2. Improve students' problem-solving skills
3. Provide facilitated help for students
4. Provide an active-learning environment for students

Over a two semester span, 500–580 undergraduate general chemistry students had the option of enrolling in the sessions. The PLTL sessions took place outside of typical class hours once per week under the facilitation of a senior peer-leader (a leader who had previously taken the course). During the sessions, students worked collaboratively to solve problems that related to current course work.

Performance results incorporated student backgrounds in order to assess their achievement level relative to a number of factors that could influence results. Researchers looked at SAT scores, income bracket (whether students were from low income backgrounds or not), and other variables. Comparing academic achievement of PLTL students to non-PLTL students indicated statistically significant results demonstrating that the former outperformed the latter with a difference in final grade averages of one grade rank (B vs. B-). Hence, participation in PLTL “had a statistically positive effect on the students’ performance in General Chemistry” (p. 995). Other variables that were explored include comparing male versus female, minority versus nonminority, and low income versus nonlow income students. Results indicated that regardless of the personal characteristics of students, the effects of PLTL were favourable. Attitudinal surveys assessed PLTL’s effect on study skills and performance, group dynamics (nine-item

survey), a student's assessment of his or her ability in chemistry, and a student's perception of study groups. Taking the attitudinal survey into account, overall results show that students had a positive experience with PLTL groups (Hockings et al., 2008).

Peer-Led Team Learning: Undergraduate Science

Peer-led team learning “typically engages students in small group discussion to work on problems or to complete tasks related to their courses” (Micari et al., 2006, pp. 269–270). The peer-led teaching sessions were situated in small groups to discuss the class topic for that day. In addition to the small group aspect shared with PLTL, each group was assigned a specific peer-lead for the sessions. The peer-lead within both of these learning strategies was both facilitator and partner in the learning process with the students. The entire group benefited from this strategy, particularly the peer-leaders, who “engage[ed] with the material at a deep level, helping solidify their own understanding of it” (p. 270). In the study done by Micari et al. advanced undergraduate students (i.e., students who had previously taken the course) played the role of facilitators in small groups. Students within different scientific fields worked as a unit on conceptual problems given to the facilitator by the professor. The goal of their study was to qualitatively examine the effect the experience had on facilitators through the administration of surveys, focus groups, and individualized interviews.

At the conclusion of the study, facilitators identified three types of growth experienced: cognitive, personal, and instrumental. Cognitive growth encompassed advances in thinking, perceptualizing, and problem-solving abilities. Facilitators overall felt a greater level of understanding and personal growth. Researchers found that facilitators were able to communicate more effectively. Instrumental growth represented

growth that went beyond the current circumstances, extending into future career choices as a result of the experience (Micari et al., 2006).

Co-operative Learning

Co-operative learning implemented within secondary school science most resembles PLTL as described in the current study. Acar and Tarhan (2008) investigated the effects of cooperative learning on students' understanding of metallic bonds. The underlying premise of their study had to do with difficulties students faced in understanding metallic bonding in grade 9 chemistry. Consequently, the researchers set out to investigate the effectiveness of co-operative learning in increasing understanding of and preventing misconceptions related to metallic bonding.

Participants were 57 grade 9 students from two classes. One class served as the control group, whereas the other was the experimental group; assignment was done randomly. Students in the experimental group participated in an achievement test (gauged prior knowledge), a metallic bonds concept test (eight multiple-choice questions gauged understanding), and semistructured interviews (identified student understanding as it related to co-operative learning). During the co-operative learning sessions, students actively participated in the learning process through asking questions, such as "What are you doing?" and "Why are you doing this?" Students investigated answers to these questions as a group (Acar & Tarhan, 2008).

Conclusions of the study revealed that students in the experimental group gained a better understanding of concepts than those in the control group. Overall, students were able to discuss, share knowledge, and apply acquired concepts. Co-operative learning supported increased scientific understanding of metallic bonding through students

collaboratively questioning and generating solutions to problems presented to them (Acar & Tarhan, 2008).

Advantages of Peer-Led Team Learning

As discussed briefly, PLTL (and its aliases) resulted in a variety of advantages for its participants. Working as a team, students were able to combine their thoughts and interdependently identify solutions to problems, “experienc[ing] positive interdependence as they work[ed] through problems in collaborative settings” (Tien et al., 2002, p. 607). Allowing students to work collaboratively and interdependently with little guidance from the teacher gives students the opportunity to become individuals who are more responsible for their successes. Ingraining independent work strategies with secondary school students lays the framework for future academic success. In addition to students gaining independent and interdependent skills, discussions played a large role in the development of those skills. Students may be less able to find the necessary resources to succeed without discussing with their peers around them, and PLTL provided that opportunity.

In the PLTL study done by Tien et al. (2002), researchers found that “PLTL provid[ed] an environment [in] which students are immersed in an intellectual community, learn to communicate scientific ideas, and work in a problem solving team” (p. 607). These skill sets aid in promoting scientific literacy in the classroom, as students learn to interact, discuss, and question by working in teams, supplementing usual classroom practices.

Overall, previous research done on implementing PLTL as a learning strategy for undergraduates illustrated an improvement in conceptual understanding, discussions,

questions, and application abilities. Students' collaborative efforts were successful in enhancing cognitive development.

Implications for Science Learning and Teaching

Current learning and teaching methods are gradually being characterized by less teacher-centredness and are becoming more focused on the active participation of all students (Hodson, 2003). As such, Rennie et al.'s study (as cited in Castano, 2008) suggested

that the ideal science education should promote the students' deep understanding of their world and impact their everyday life. They found that many science classes, mainly in secondary schools were teacher-centred and covered too much content, resulting in a lack of interest, excitement, and curiosity among students and their perception that science learning is irrelevant for their lives. (p. 568)

In order for students to gain an enriching learning experience and to consolidate knowledge into understanding, students will need to be actively involved in the learning process, being taught with instead of just taught to (Hodson, 2003; Osborne, 2002).

Particularly in the field of science, teaching to is not the most effective means to convey information that will result in conceptual understanding (Castano; Eberlein et al., 2008).

In higher levels of science, for example within secondary school, a lot of content may be taught within a short period of time. The mind has limitations on the amount of information that can be grasped within in a particular period of time; hence, Eberlein et al. state, "a strategy that attempts to transfer knowledge more or less directly from teacher to student – 'teaching by telling' is ineffective for many if not most students" (pp. 262–263). Students need time to consolidate new information. Providing learners with a brief

period of making sense of the material through a learning strategy such as PLTL would benefit students.

Furthermore, developing an understanding of abstract concepts occurs when students “actively build for themselves a workable understanding of sophisticated concepts and must be engaged in developing their own higher order thinking skills” (Eberlein et al., 2008, p. 263). PLTL is a strategy which allowed students to take control of their own cognitive development through discussing, questioning, and applying concepts learned in class. As well, exploring how a topic relates to the world around you supports cognitive growth. Rennie et al. (2001) suggest that students need to be guided to see the relevance and importance of understanding scientific content.

Issues

Although PLTL and its various derivatives are said to improve discussing, questioning, and applying concepts resulting in increased academic achievement, much of the current literature focuses on its applications within elementary and postsecondary institutions. Studies previously done within elementary schools looked at peer sessions to improve literacy skills (Berne & Clark, 2008) and learning in small groups (Kamps et al., 2008). In secondary schools, studies explored how teacher-structured co-operative groups promoted learning of tasks or concepts throughout a unit (Acar & Tarhan, 2008), which may not be a realistic option for many secondary science teachers who are faced with time constraints in covering the curriculum. In postsecondary institutions, studies looked at peer teaching in terms of teaching assistants or peer-tutors (Micari et al., 2006; Ramaswamy et al., 2001). Within this spectrum peer sessions relating to science content were studied. Secondary school studies on peer teaching sessions included studies on

supporting students with disabilities (Bond & Castagnera, 2006) and chemistry sessions (Tai & Sadler, 2007). There is a need for further studies in all of these areas; however, focusing specifically on secondary school science curriculum provides advantages which would be evident in postsecondary education. Participation in PLTL may have helped students to develop independent work ethic, a comfort level discussing the day's topic, and postulating solutions with little aid from the instructor. The advantages would be seen in students' ability to work independently with minimum instructor guidance.

Conclusion

Overall the implementation of the PLTL strategy provided numerous opportunities for growth and improvement. Peer to peer teaching/tutoring has been used for a number of years within classrooms to consolidate knowledge (Micari et al., 2006). Research shows that developing the skills to discuss, question, apply concepts reviewed, and relate to what is being learned increases meaning. Research has suggested that "peer tutoring and cooperative learning [strategies] can yield significant gains in academic achievement" (Topping, 2005, p. 635). Exploring whether or not similar results were obtained within secondary schools has implications for future research and practice. Chapter Three will present indepth the methodology for developing the quantitative and qualitative investigation of the PLTL implementation.

CHAPTER THREE: METHODOLOGY AND RESEARCH DESIGN

This study used mixed methods in order to investigate the effect PLTL sessions had on students' conceptual understanding of evolution concepts and students' attitudes towards PLTL. The design of the study utilized methodologies of previous PLTL studies as implemented by Tien et al. (2002). Their study included pre/posttests, a questionnaire, and interviews. The current study used the same methods; however, the Tien et al. study was a longitudinal study, versus the current study which investigated effects of PLTL within one classroom over a short period of time. This chapter will review the following: (a) research methodology and design, (b) selection of site and participants, (c) instrumentation including reliability and validity, (d) classroom procedures, (e) data collection and recording, (f) data processing and analysis, (g) methodological assumptions, and (h) ethical considerations.

Research Methodology and Design

In this study conceptual understanding was defined as the ability to construct, expand on the meaning, and apply scientific concepts by drawing on prior knowledge gained from personal everyday experiences with the phenomena and knowledge of scientific concepts gained through formal science instruction (see Figure 3).

Using this definition and the same premises described in the previous undergraduate studies in the literature review (promoting discussions, questions, and applications of what was learned in class through small groups), the current study provided secondary school students with experiences similar to those experienced by undergraduate students.

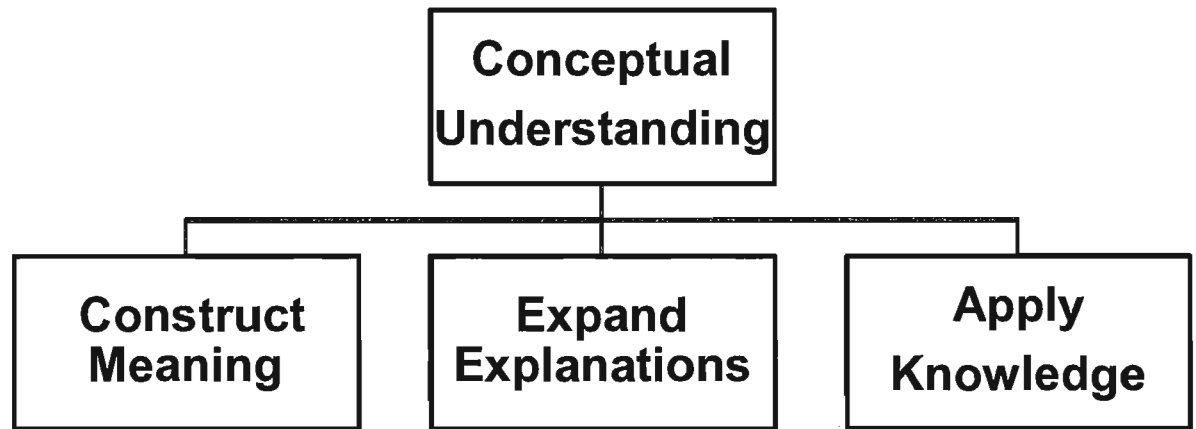


Figure 3. Conceptual understanding.

A mixed methods approach was used for the current study. This approach was appropriate, as the purpose of the study was to identify the effect of PLTL on students' conceptual understanding as well as investigating students' attitudes towards PLTL. According to Creswell and Clark (2007), the mixed methods approach offsets the weaknesses of using just either quantitative or qualitative methodologies, providing a well-rounded investigation that helps to answer questions through combining the strengths of both methods. In this study the two data sets worked to support each other. Quantitative data were gathered from test scores which could further be interpreted through the analysis of qualitative data generated through the questionnaires and interviews, allowing the researcher to gain insight into how students experienced the PLTL strategy.

This mixed methods research is further classified as quasi-experimental as participants being studied were not randomly allocated into control and intervention groups (Muijs, 2004). According to Muijs, "quasi-experimental research is especially suited to looking at the effects of an educational intervention" (p. 27). Classes are typically preestablished in schools; as a result, the experimental group is determined by those that volunteer or are selected to be part of the intervention. Gaining insights into how participants experience a phenomenon is particularly suited to qualitative research methodology as the latter involves the study of phenomena in natural settings (Denzin & Lincoln, 2000). The current study explored a teaching intervention in a natural setting, the school, and also attempted to make sense of how students experienced the intervention. As such, observation and interviews were appropriate methods to gain insights about participants' experiences and feelings about the PLTL sessions.

Similarities of the current study to previous studies included comparing grade assessment (Hockings, DeAngelis, & Frey, 2008), utilizing a questionnaire (Tien et al., 2002), and asking students to participate in an interview (Acar & Tarhan, 2008; Tien et al.). One of the differences from the other studies was that small group sessions were held within class time, and peer-leaders were facilitated by the teacher as well. Additionally, this study did not have a comparison group because it took place within one classroom. Doing a smaller scale study allowed the current study to investigate whether or not large-scale investigations would be warranted.

The current study used an investigative approach that was most similar to the Tien et al. (2002) study. The current study investigated the implementation of PLTL in one classroom, versus having two groups where one serves as a comparison group. Consequently, test scores were compared between PLTL sessions versus non-PLTL sessions with the same group of students in contrast to the Tien et al. study which incorporated two groups, one of which was a nontreatment group. However, both studies utilized questionnaires and interviews in order to generate qualitative data. In the current study, students completed an attitudinal questionnaire upon the completion of the study, and a selected number of students were interviewed. This mixed methods approach allowed data to be collected for quantitative and qualitative analysis.

Repeated Measures Design

Repeated measures design investigates an intervention within a single group (Black, 1999). This design allows the researcher to control for extraneous variables as the participants represent both the intervention and nonintervention groups (Black). This design was used rather than two groups for specific reasons. Unlike the Tien et al. (2002)

8-year longitudinal study, the scope of the current study needed to be small, yet provide information to make a worthwhile research project. Consequently, the time frame of the research was an important factor in making this decision. Generally in two-group setups, two similar groups of students with similar makeup, background, and teacher would be used in a study (Muijs, 2004). The limited resources (e.g., teacher volunteers in a school teaching the same subjects) and small scale of the current study made it difficult to find such a group of students. Consequently, for simplicity and lack of two classrooms with similar makeup, repeated measures design was chosen. This research design choice reduces some threats to validity as there is less variation when comparing test result scores when using the same group of people.

This study design created a comparison group within the single group being studied. Utilizing the repeated measures aspect, the same students were exposed to the intervention twice with successive breaks (i.e., non-PLTL sessions followed by PLTL sessions). This four-stage setup meant that within one session (which lasted 4 weeks) students were exposed to the intervention twice (PLTL) within one unit of study. In addition to the PLTL sessions, students also participated in pre/posttests which were used to compare before and after intervention, between intervention periods, and nonintervention periods.

Variables

Since the purpose of this study was to investigate whether or not the implementation of the PLTL strategy influenced students' conceptual understanding of scientific concepts, looking at academic achievement scores was one means to assess this. The tests administered specifically examined students' scientific conceptual

understanding in relation to the following cognitive processing categories: interpreting, exemplifying, classifying, summarizing, inferring, explaining, executing, and implementing learned tasks (Anderson & Krathwohl, 2001). These categories are explained in the instrumentation section. Students' test scores in these areas were identified as the dependent variables. Whether or not student academic achievement/test scores increased depended on their performance; hence, academic achievement/test scores was the dependent variable. The independent variable was the PLTL intervention.

Research Questions

1. What impact did the PLTL instructional strategy have on grade 11 students' conceptual understanding of evolution?
2. What were students' attitudes towards the PLTL instructional strategy?

Null Hypothesis: There will not be a significant difference in achievement scores between PLTL sessions and non-PLTL sessions.

Research Hypothesis: Academic secondary school students' conceptual understanding, as measured through achievement scores, can be improved through PLTL sessions.

Preliminary Fieldwork

Due to a lack of current literature in the area of secondary school implementation of PLTL, an internship on current instructional strategies in secondary schools was done in winter 2009 (as described in Chapter One). I spent one month in the teacher's classroom becoming familiar with the teaching strategies used to teach biology. My observations of this teacher and other science teachers at the school indicated that PLTL was not incorporated as a strategy in these secondary school classrooms. Consequently, the current PLTL study was designed in such a way as to enhance current classroom

activity by allotting a short period of time for PLTL sessions over a 4-week session rather than over a few months.

Selection of the Site and Participants

Due to the small scale of this study, choosing the sample population randomly was not a plausible option. As a result, the sample population was chosen based on convenience sampling (Black, 1999) where the sample population was chosen based on circumstances convenient to the researcher.

Consequently, the secondary school was chosen because of prior involvement with the school through an internship placement in winter 2009. For the current study, a group of grade 11 secondary school science students was selected from an urban area midsized school. Access to the site was granted by the school board, principal, and teacher after delivering an overview of the study and anticipated benefits to the school community through a research application process. Additionally, prior to the recruitment of students, the Brock Research Ethics Board reviewed the proposed research and granted clearance (see Appendix A). Secondary school students from the class were invited to participate in the study through a letter of invitation, followed by a consent form which outlined all of the procedures and the expected benefits to the students. Due to the nature of this study, all students were expected to participate in the PLTL session as part of regular classroom instruction; however, access to grades, questionnaire, and interviews was an optional portion of the research, and student permission was obtained to collect these data.

Participants

The secondary school grade 11 class consisted of 23 students. Of the 23 students, 3 chose not to allow the collection of data pertaining to their grades; however, all students participated in the PLTL sessions and pre/posttesting. Furthermore, 1 student was consistently absent from class; as a result, her data were also eliminated. At the conclusion of the study data from only 19 of the 23 students were collected to be used in the research investigation. Participating students included 8 males and 11 females.

A history and attitude questionnaire towards science (see Appendix B) was administered to students prior to the commencement of the study in order to develop an understanding of students' backgrounds. Questionnaire responses were used to determine who would participate in the interviews. Following the collection of questionnaire responses, questionnaires were reviewed and 4 interviewees were chosen as a result of their responses. Four students, 2 male and 2 female, responded quite differently; 2 of them had highly positive feedback, and 2 of the students had more constructive/negative feedback. In order to get a balanced perspective of the overall implementation of the PLTL sessions, those students were chosen to be interviewed.

Participating students reported that no students had previously taken the grade 11 academic biology course and none had received prior tutoring or had taken science courses in the summer. Of the surveyed students, 38% reported that they understood scientific concepts, 24% were unsure, 86% agreed/strongly agreed that science was relevant to their futures, and 57% believed that they wanted to pursue science-related careers.

Instrumentation

The following section describes the instruments developed for the implementation of PLTL sessions which include: description of tests and measures, questionnaire, interview guides, observation guides, and the validity and reliability of the various instruments.

Description of Tests and Measures

Tests were developed by the researcher using prior tests (written in previous years by the teacher), example questions from textbooks, and input of experts in the area (teacher and faculty member). Guidelines presented by Anderson and Krathwohl's (2001) *A Revision of Bloom's Taxonomy* provided the structure for the tests.

The tests were specifically constructed to measure students' conceptual understanding. As outlined in Chapter Two, conceptual understanding refers to a student's ability to not only identify and label terms but also construct and expand on explanations of concepts in the topic given and apply that knowledge in a new situation, using prior knowledge. Anderson and Krathwohl (2001) outline cognitive processing dimensions that relate to conceptual understanding. These cognitive processing dimensions go beyond the initial remembering category of recognizing and recalling and into understanding—"construct[ing] meaning from instructional messages" (p. 31) and applying—"carry[ing] out or us[ing] a procedure in a given situation" (p. 31), categories of cognitive processes. The understanding category examines students' abilities to interpret, exemplify, classify, summarize, infer, compare, and explain information presented to them. Conceptual understanding is further measured by looking at students'

ability to apply what was learned through executing and/or implementing a task in a particular scenario.

The grade 11 biology unit of study was evolution. The unit was broken up into four subtopics, and tests were prepared for each subtopic: History of Evolution (Appendix C), Patterns of Selection (Appendix D), Speciation (Appendix E), and Hardy-Weinberg (Appendix F). Each test was formatted to assess students' conceptual understanding, and each test utilized the following setup: modified true/false, matching, and short answer.

The modified true/false section asked students to categorize six or seven questions as either true or false, and if it was false to change the italicized word to make the sentence true. An example true/false question follows:

Hummingbirds and butterflies both have wings. This is considered to be an example of *homologous* structures _____. In this case the answer was false, as having wings is an example of an analogous structure. Each of the questions in the modified true/false section fell into the cognitive processing dimension of either remembering or understanding evolutionary concepts.

Following the modified true/false section was a matching section where students had to match the statement or fill in the blank, choosing a word in the adjacent column.

An example of a matching statement follows:

LEFT-HAND column

RIGHT-HAND column

The concept of inherited traits being
combined from each parent

combined inheritance

The matching section examined students' cognitive processing dimension of understanding concepts, much of which involved inferring and interpreting processes.

The last section of the test was a short answer section. In this section students were asked to demonstrate their conceptual understanding through the cognitive processing dimensions of understanding and/or applying an evolutionary concept. For example: Explain how cumulative selection provides a scenario for the evolution of the eye from an organism which has developed a patch of photosensitive cells, to the formation of a crude lens. Explain how these changes would benefit the organism. This question examined students' understanding of cumulative selection and its role in evolutionary advances. In the short answer section it was important for students to understand concepts in order to express answers which illustrated their conceptual understanding.

The tests were scored out of 15. Students received 1 mark for each correct modified true/false and matching question and received up to 3 marks for adequately answering the short answer question. The pretest scoring was done by the researcher, and the posttest scoring was done by the teacher. Marking schemes between the two tests were discussed by the teacher and the researcher. In order to maintain consistency in the grading, an example marking scheme was followed.

Questionnaire

The questionnaire was designed to gauge student attitudes towards the implementation of the sessions. Utilizing a 5-point Likert scale, the questionnaire listed five statements. Each statement reflected the attitudes of students, taking into account their attitudes towards discussions with peers, their understanding, and their confidence

level. The sixth question, asked the students to rate their overall experience with the PLTL sessions (see Appendix G). Each statement was responded to using the numbers 1 to 5, where 1 represented strongly disagree, to 5 representing strongly agree. The last item presented was a question rather than a statement. In the sixth question, responses ranged from 1 being very negative to 5 being very positive. The research questions of the study aided in the design of the questionnaire. The questionnaire was validated prior to the study by a group of nonparticipating grade 12 students who had previously taken the course. They provided feedback on the content and clarity of instruction, and the questionnaire was modified accordingly.

Interview Guides

Interview questions (see Appendix H) were developed by the researcher. Questions being asked to students related closely to questions on the questionnaire; however, rather than statements, students were asked open-ended questions. Each question determined students' feelings about the study and their reasons as to whether or not PLTL sessions should continue in the classroom.

Observation Guides

In order to triangulate data, a researcher observational log became part of the design. The purpose of the observational log was to record my observations of student interactions. I documented their small group interactions, the discussions taking place, questions being asked, and concepts being applied. Keeping an observational log served to enrich the overall data, as observations of students' expressions, tones, and body language provided in-depth data to support previously established qualitative and quantitative aspects of this study (see Appendix I).

Validity and Reliability

Validity refers to checking the quality of the data and results and varies between qualitative and quantitative research. Pertaining to the quantitative aspects of this research, “validity means that the researcher can draw meaningful inferences from the results to a population; reliability means that the scores received from participants are consistent and stable over time” (Creswell & Clark, 2007, p. 133). Validating results is a measure to ensure that data collected can be used to draw valid conclusions and as a result findings can be applied to the population (Statistic Solutions, 2009). Reliability refers to the consistency of measures; consistency within testing suggests that the data collected would have a greater reliability if a scale produces consistent results (Statistic Solutions, 2009).

Generally, instruments are validated as result of prior development by experts in the field. However, in the current study the tests were developed by the researcher. Similar tests used by the classroom teachers in the past to assess student understanding of that content along with information supported from the textbook provided the basis for test development. In constructing the tests, reference was made to Anderson and Krathwohl’s (2001) *A Revision of Bloom’s Taxonomy* which discusses the cognitive processing dimensions involved in learning. Using Bloom’s taxonomy as a guideline, specific cognitive processes pertaining to the development of conceptual understanding were integrated into the tests. Additionally, the expertise of the classroom teacher and thesis advisors played a role in the validation of the tests. A faculty member, an expert in the field of assessment and biology, reviewed the content of the evolution tests along with checking for consistency in the wording and clarity. Furthermore as discussed, a

group of nonparticipating 12th grade students were selected to evaluate the clarity of the questions, identifying any misconceptions presented in the wording of the tests. Students' input added to the reliability of the study, maintaining consistency in the wording throughout the tests.

Qualitative validity refers to “assessing whether the information obtained through the qualitative data collection is accurate” (Creswell & Clark, 2007, p. 134). In this study qualitative validity was accomplished through triangulation, comparing similar data which reinforced the conclusions of each data set. Triangulation was accomplished through comparing data obtained from classroom observations, questionnaires, and interviews. Observations of classroom interactions, questionnaire responses, and coded thematic interview responses were contrasted, providing information about the consistency of inferences based on results obtained from these data sets.

Research Design

The research design involved reviewing the procedures of the timeline, peer-led teaching sessions, instructions to the participants, and structure of the PLTL groups.

Timeline

The research and the collection of data took place over a 4-week period for one unit of study, evolution. For each subtopic, students wrote a pretest; then the teacher taught the science subtopic. This was followed by independent work periods and a posttest. Two of the subtopics had PLTL sessions prior to the posttest. Pre- and posttests took approximately 15–20 minutes. The implementation of the PLTL sessions lasted between 15 and 20 minutes. After the completion of the last posttest, students were presented with a questionnaire that took approximately 2 minutes to complete. The

subtopics were taught over a range of 3–5 days, some with greater periods of teacher instruction and others with greater time allotted to independent work. At the conclusion of the study, 4 students were chosen to be interviewed independently for approximately 5 minutes.

Peer-Led Teaching Sessions

This research involved implementing the PLTL strategy within the regular context of teaching in order to identify how its implementation affected conceptual understanding as evidenced in student achievement. The following outlines the classroom procedures that were followed for implementing PLTL sessions:

- Pretests took place prior to teaching the lesson, identifying prior knowledge base of the students.
- Instructor (teacher) taught a subtopic of the evolution unit to the class.
- After the subtopic within the evolution unit was completed, students were placed into small groups as directed by the teacher (ensuring balance, academic strengths/weaknesses in groups).
- After groups were assigned, one member of each group was assigned to the position of group lead based on high academic performance.
- Each student received instructions clearly outlining his or her role in the group, and the researcher provided examples of how student facilitation occurs.
- Students not assigned the role of lead were asked to generate relevant and thought-provoking questions to add to group discussions and write them down in preparation for PLTL sessions.

- The PLTL sessions took place for the first 15–20 minutes of the 85-minute class on the day of the scheduled posttest.
- Following the PLTL session students received the posttest pertaining to the subtopic taught.
- The next subtopic taught within the unit was not followed by a PLTL session (i.e., non-PLTL session); however, the posttest followed an independent work period (typically consisting of reading and answering questions from the textbook).
- This procedure was repeated for the next two subtopics.
- Following the last posttest of the unit, students received the attitude questionnaire.

Teacher-Led Classroom Instruction

During the PLTL sessions the teacher taught the grade 11 biology students according to his regular teaching practices. A typical class lesson consisted of PowerPoint slides, examples on the board, question periods, and independent textbook work. During the 4-week evolution unit students were initially to be tested on the following four subtopics: History of Evolution, Natural Selection, Patterns of Selection, and Speciation. Each unit was prefaced by a pretest which was used to assess students' prior knowledge base and compare with posttest scores. Prior to the pretest, students should not have had any teaching on the particular subtopic of study. However, prior to the pretest for the subtopic 2, Natural Selection, the teacher taught Natural Selection along with the History of Evolution, subtopic 1. As a result, an alternate unit was added to the end of the unit, Hardy-Weinberg Principles, which became subtopic 4. Natural Selection was removed from the subtopic list at the suggestion of the teacher. The History of Evolution posttest, following the original order, was given to students after the

teacher taught the subunit. PLTL sessions did not take place during subtopic 1. Following the History of Evolution posttest, students were given the Patterns of Selection (subtopic 2) pretest. After the teacher taught the section on Patterns of Selection, students were told in detail about a PLTL session that was to take place prior to their posttest on Patterns of Selection. Following that subunit, the third subtopic, Speciation, was taught and pre/posttest sessions took place without PLTL sessions. The last subtopic, Hardy-Weinberg, included a PLTL session prior to the posttest.

Peer-Led Team Learning Sessions Leads and Group Instruction

The following section outlines instructions given to participants including the peer-lead and peer group members. Additionally, this section describes how the peer-led team learning groups were organized.

Peer-lead instructions. The night before the PLTL sessions, the lead was required to write a brief summary of the key topics discussed during the previous lessons on the topic of study for that week. During the session the leads initially gave a brief synopsis of the main topics discussed by the teacher, after which they opened the forum to the rest of the group. Students then presented their thought-provoking questions or questions of concern to the group for discussions.

Peer group instructions. A day before the PLTL sessions, students were asked to review their notes of the unit presented that week and generate questions that were of concern to them or a thought-provoking question to present to the group. During the PLTL sessions students were asked to present their previously written questions to the group and, working together, they attempted to generate answers and solutions, which were also written down. A sample of guideline questions was also provided for students

on the blackboard on the day of the PLTL session (see Appendix J for examples) to aid students in generating ideas about the week's topic.

Peer-led team learning groups. Students were placed in five groups of 5–6 students for the PLTL sessions, and each group was assigned a peer-lead. Initially the five group leads were students with the highest marks; the remaining students, ranked from highest to lowest grades, were then dispersed among the groups equally. This method was decided on by the teacher and the researcher, the hope being that the students' academic performance levels would be equally balanced among the groups. Students with the highest grades were chosen as leads for consistency among the groups and for what appeared to be a greater knowledge base on scientific concepts.

The day before the first PLTL session group, leads were asked to write a summary relating to the subtopic, and group members were asked to write a question pertaining to something they had difficulty with or any question to which they wanted answers regarding the subtopic. On the first PLTL session day students were placed in their groups and situated in different areas around the classroom. As the researcher I walked around the classroom during the PLTL session, listening to the leads' brief summaries and students' questions. Each group member was asked to write his or her question down, and, to ensure they were answered, students had to write down student responses to their questions. The questions were collected, but the leads' summary notes were not collected, as students wanted to use them as study notes for their final test. After observing the different groups and their dynamics, it was noted that one group in particular did not have much group discussion; students paired off and discussed between themselves rather than discussing as a group. The lead in particular had a difficult time

explaining concepts he understood to other group members who did not grasp the concept; additionally, some students were missing. As a result of this observation, at the next PLTL session members of that particular group were resituated among other groups.

Questions. The questions students brought to their small groups varied, depending on the individual. Students were asked to write down questions which were relevant to them. Consequently, most questions focused on items students had difficulty understanding during the week's lesson. Some of these questions may or may not have related to questions on the test. As noted through my observations and sheets collected with student questions, students' questions were based on developing an understanding for content rather than focusing on recalling questions from the pretest given.

Adjustments. The day before the last PLTL session and posttest, students reviewed orally the role of the leads and the role of the group members. On the day of the last session, a number of leads forgot to write a summary, so students spent the majority of time answering questions. If students had difficulty coming up with a question the night before, they could listen to student conversations and generate a question in response to any information they acquired during the PLTL session. These adjustments were made according to interactions witnessed among the students.

Data Collecting and Recording

The following section outlines the methods of data collection and recording as it pertains to the quantitative and qualitative methodologies. Each section briefly describes how the data were collected and for what purpose.

Data Collection

Collection of quantitative data included pre/posttests. Qualitative data collection included questionnaire, observational protocol, and interviews, which are outlined in the sections to follow.

Quantitative data. Quantitative data were collected through pre/posttests. Pretests done prior to the teacher teaching a subunit gauged students' prior understanding. The same pretest was then used later for the posttests, which specifically assessed students' conceptual understanding of the topic. The posttests took place following PLTL or non-PLTL sessions depending on the week.

Qualitative data. Qualitative data were gathered from the attitude questionnaire, observational field notes of two PLTL sessions, and collected student questions and responses during PLTL sessions and interviews.

The attitude questionnaire (see Appendix G) was administered to develop an understanding of student attitudes towards PLTL. (Note: If students had chosen not to participate in the study they did not participate in the questionnaire.) The questionnaire was given after the final posttest.

Observational field notes were used to enrich the understanding of both qualitative and quantitative aspects of the data. External observations of the researcher provided data that reflected whether or not student interactions, positive or negative, were representative of data presented through the questionnaires and interviews. Hence, field notes served as a means to triangulate the qualitative data gathered through interviews and questionnaires. Furthermore, these data were supported by questions and answers

students had prepared and written during PLTL sessions which were collected to be included with the observational field notes.

Interviews played a major role in gaining an understanding of student attitudes and feelings towards PLTL. Four students (2 male and 2 female) were interviewed for 5 minutes each after the final peer-teaching sessions, being audio-recorded, reviewing their personal thoughts and opinions. Students who were willing to participate in the interview were chosen based on their questionnaire responses whereby positive and negative respondents were chosen (2 male and 2 female students). The interviews took place during class time within an empty classroom adjacent to their usual classroom. Confidentiality was not breached as students were interviewed independently.

Data Recording

The following data recording section reviews quantitative and qualitative data sources. This section also identifies the methodologies involved.

Quantitative data. Quantitative data from pre/posttests were recorded by the teacher, and each of the participants was identified through a numerical code. Prior to coding, the teacher removed grades for students who had chosen not to participate in the study. Following each pretest, coded tests were graded by the researcher, and following each posttest the teacher graded the posttest results and grades were given to the researcher. As the researcher I did not receive the posttests, just the coded test scores, to maintain confidentiality of the students. The marking scheme was agreed upon through discussions with the teacher. For the true/false section students received only 1 mark per question if they wrote true or false, and if they wrote false, they had to write the correct answer in order to obtain full marks. The matching was also worth 1 mark, and students

had to match correctly in order to obtain full marks. For the short answer section, the teacher was given an example answer for each subtopic which reflected all the main components that should be present within a student's response for the full 3 marks. Prior to each pre/posttest the teacher had a master copy of the tests with complete answers to use as a guideline for the marking scheme.

Qualitative data. Qualitative data recordings, as mentioned earlier, included observational field notes, questionnaires, and interviews. Field notes were recorded into the observation chart and were viewed by only the researcher and her advisor. The questionnaires were not coded; however, confidentiality was maintained, as interviewees were chosen based on questionnaire responses. Half of the students interviewed were representative of positive feedback, and the other half negative feedback. Interviews were audio-recorded and transcribed.

Data Processing and Analysis

Data processing and analysis section pertains to the observational field notes, interviews, tests, and questionnaires. Each section outlines the procedures involved in processing and analyzing these data.

Observational Field Notes

Field notes were used to supplement the data obtained through the interviews and questionnaires through reviewing questionnaire answers in relation to interview responses and observed interactions. Themes were generated through coding of field notes and comparing to questionnaire and interview responses.

Interviews

The 5-minute audio-recorded interviews were transcribed by the researcher for analysis. Data generated from the interviews were coded (dividing text into small units), evidence was grouped, and ideas were labelled in order to reflect a broader perspective to generate themes (Creswell & Clark, 2007). As common themes were drawn out through comparisons, statements were made regarding findings (discussed in Chapter Four). Themes generated were then compared and contrasted to questionnaire responses. The two data sets worked to support each other. Observational data also supplemented inferences made.

Tests

Data obtained from the pre/posttests were analyzed using the software SPSS version 18 to compare the grades. Table 1 describes the experimental setup, denoting the weeks of PLTL implementation and outlining the subtopics discussed within the unit. Following teacher instruction, students either wrote the posttest at the usual designated class period or participated in the PLTL session prior to writing the posttest depending on the week. Since this was a repeated measures design, the PLTL sessions were repeated twice. However, the sessions were not repeated consecutively but occurred on a biweekly basis. As such, students had a week without PLTL intervention followed by a week of PLTL intervention, as illustrated in Table 1.

Initially, two levels of analysis were to be done on the tests: analysis 1, comparing pre/posttests grades through a paired samples t test, and analysis 2, comparing means between only pretest and then only posttest scores, also done through a paired samples t test. However, only analysis 1 was completed. Analysis 2 was not completed

Table 1

Repeated Measures Design

Week	Pretest	Teaching session topic	Sessions	Posttest
1	Pretest 1	History of Evolution	No PLTL	Posttest 1
2	Pretest 2	Patterns of Selection	PLTL	Posttest 2
3	Pretest 3	Speciation	No PLTL	Posttest 3
4	Pretest 4	Hardy-Weinberg	PLTL	Posttest 4

because after comparing the pretest means only, it was noted that differences were found between pretest means as a result of inconsistencies in the implementation of the pretest scores, which tainted the results.

Questionnaire

The data collected were analyzed by tabulating the numbered responses into percentages that were displayed in bar graphs. These data were further analyzed by contrasting the responses in the questionnaire to responses of the interviewees, as modelled through previous studies.

Methodological Assumptions

In this study it was noted that all students participating had not previously taken a course at that school or any other school with the same content. Additionally, it was presumed that none of the students had previously been diagnosed with a learning disability. Furthermore, students should have had some prior scientific knowledge basis to provide a framework for continued growth and learning.

Limitations

The design of the study, repeated measures, was chosen due to the convenient sampling of retesting the same group of students. However, utilizing only one group in a mixed methods study may have limited the generalizability of the results. The study was limited in the following areas: recruitment, design, and tests.

Typically quantitative methodologies attempt to investigate correlations by recruiting more than one group of the same general makeup of participants; hence, choosing participants is typically done randomly. However, the current research being quasi-experimental allowed for participants to be chosen using convenient

sampling procedures. Random recruitment of participants might have strengthened results, as participants chosen randomly decrease the chances of researcher bias and/or prior interactions that may have occurred with the participants, which may influence how results are interpreted and/or how participants interact with the researcher. Students, teachers, and schools being chosen randomly might have provided data that were more representative of the population, which would allow results to be generalized to a population. The consequences of nonrandomization were minimized by the researcher not having any prior interactions with the students leading to biases and or misleading data.

Limiting factors in the quantitative design of the study included aspects of repeated measures design. Repeated measures design allows for the same group of students to be exposed to the same learning strategy on more than one occasion. This limited findings, as students who had a positive or negative experience with the PLTL sessions the first time may have anticipated enjoying or disliking it the second time. As a result, students may have changed their school study habits to further facilitate/not facilitate the group discussions, questions, and application portion of the sessions, which could have led to results which do not reflect changes as a result of PLTL.

The one-group aspect of the study also limits the generalizability of the results. The makeup of the participants at school was not representative of the general population; as such, making inferences from the results to larger populations is difficult to accomplish. Additionally, the number of participants actually participating in the PLTL sessions was limited, reducing the data obtained in order to generate meaningful conclusions from the results. Furthermore, not including a comparison group, a group of

students not exposed to PLTL sessions, may have led to results that were not representative of changes due to PLTL but may have been due to a number of other external factors such as students' test preparation, work ethic, and level of participation in class not accounted for in this study.

Tests were developed by the researcher with the aid and guidance of experts in the field. Experts in the field included the teacher of the class and a faculty advisor who was also a former science teacher. Both of these experts gave critiques on the tests, ensuring that wording was organized to promote conceptual understanding through clear, concise language. In addition to careful development, a group of eight students who had previously taken the course reviewed the actual phrasing, clarifying question presentation. Despite the precautions taken in the development of the tests, students could have interpreted questions incorrectly and as a result erroneously/correctly put down an answer which may/may not exhibit actual conceptual understanding of the topic. Consequently, test grades may not be an actual representation of students' conceptual understanding of evolutionary concepts.

Pretests and posttests testing procedures may have also influenced the results. The pretests and posttests were the same. The time between the pre- and posttests was not significant and as such pre/posttest effect may have occurred, only 3–4 days between pre- and posttests. Such a short time between tests could allow students to recall content on the pretest; hence, students may have specifically studied more for those questions being asked.

Furthermore, how the teacher taught content could be regulated only to a certain extent. During my observations within class it was evident that some subtopic contents

were taught prematurely, prior to the pretest being given. As a result, students' prior knowledge could potentially influence their pre- and posttest scores due to uncontrolled exposure to the content being studied. Additionally, some lessons taught required more time in terms of the teacher teaching and independent work (students answering textbook questions). Variations between length of time taught and independent work periods may have affected student performance between testings. Not controlling for these variables may have altered findings and limited data interpretations.

Overall, there were a number of limiting factors in the study, some of which have been addressed to the best of the ability of the researcher. Despite the limitations, the results of this study could further future development in the area of PLTL in secondary school classrooms.

Ethical Considerations

All information students provided was considered confidential; students' names were not included or in any other way associated with the data collected in the study. Student feedback on the PLTL sessions and grades on pre- and postassessments or other data reported to the researcher remained confidential. Furthermore, students were not identified individually in any way in written reports. A pseudonym was assigned to each student during the interviews to ensure confidentiality. Pre- and posttest marks were coded by the science teacher before giving the information to the researcher, maintaining anonymity. Data were used as a means of assessing the effectiveness of the instructional strategy rather than assessing a student's ability. The only people having access to the data were the researcher and her supervisor. All data (including data not analyzed for the

findings or collected from participants who withdrew from the study) were kept by the principal researcher in a locked file cabinet in a secure office.

Restatement of the Area of Study

The purpose of this study was to investigate the effect of PLTL on students' conceptual understanding of evolution and students' attitudes towards PLTL, through a mixed methods approach. Research question 1 asked: What impact does the PLTL instructional strategy have on grade 11 students' conceptual understanding of biology concepts related to the topic of evolution? This question was answered through pre/posttesting, comparing whether there was a significant difference or not in mean scores between tests. Research question 2 asked: What are students' attitudes towards the PLTL instructional strategy? A questionnaire, interviews, and the observational protocol were triangulated to compare student responses, which provided an understanding of student attitudes. The results of these investigations are presented in Chapter Four.

CHAPTER FOUR: PRESENTATION OF RESULTS

The purpose of this investigation was to identify the effect of PLTL on secondary students' conceptual understanding of evolution and students' attitudes towards PLTL. A mixed methods approach was used. This study implemented a repeated measures design within one secondary school classroom where the same group of students served as both the control and experimental group.

Question 1 asked how PLTL impacts students' conceptual understanding. This question was investigated through pre/posttesting, where a paired samples t test was done to identify the effects of PLTL on conceptual understanding. The second research question aimed at identifying students' attitudes towards PLTL, which was investigated through questionnaires and interviews.

The following sections present the results of the investigations. Section one deals with findings associated with the first research question, and section two presents findings as it pertains to question 2.

Research Question 1

The first research question, what impact does the PLTL instructional strategy have on grade 11 students' conceptual understanding of biology concepts related to the topic of evolution, was addressed through pre/posttesting. An analysis of pre/posttest results was done using the software SPSS. Data gathered over a 4-week span were analyzed using paired samples t tests to compare the means of pre- and posttests.

Paired Sample Statistics

Comparing pre/posttests involved using a paired samples t test to compare means between samples. The purpose of the pretests was to assess students' initial knowledge

base of the topic. That same pretest was then later used as the posttest, assessing students' conceptual understanding as a result of teacher instruction and biweekly PLTL sessions. A paired sample t test was performed using the software SPSS to analyze the four sets of pre/posttest results. Table 2 displays the paired sample statistic results for the four tests.

The results from the t tests for paired sample indicated a statistically significant difference between pre- and posttests for: History of Evolution pretest and History of Evolution posttest ($t = 10.235$, $df = 17$, $p < 0.05$, two-tailed), Patterns of Selection pretest and Patterns of Selection posttest ($t = 9.177$, $df = 18$, $p < 0.05$, two-tailed), Speciation pretest and Speciation posttest ($t = 7.112$, $df = 17$, $p < 0.05$, two-tailed), and Hardy-Weinberg pretest and Hardy-Weinberg posttest ($t = 4.754$, $df = 17$, $p < 0.05$, two-tailed). These results show a significant difference in mean scores between all pre- and posttests and indicate that both PLTL and non-PLTL sessions resulted in enhanced conceptual understanding of the subtopics.

Paired Sample Statistics Part Two

In order to find out whether or not there was a statistically significant difference between mean scores, a paired samples t test was performed on the pretest scores. Upon completion of mean comparisons it was evident that inconsistencies were present in the pretest scores. This is a result of methodological errors such as the different ways the teacher provided instructions to the students prior to each test (for example, not telling students they were having a test before the first posttest; therefore, students did not study, versus telling students to prepare for the subsequent posttests), differences in provision of content knowledge related to the unit prior to the pretest, and sample size. Given the problems associated with comparing means for inferential statistics, no statements can

Table 2

Paired Sample Statistics

	Test	Mean	<i>N</i>	Standard deviation	Std. error mean
Pair 1	History of Evolution	32.967	18	11.3144	2.6668
	Pretest				
	History of Evolution	61.750	18	15.0879	3.5562
	Posttest				
Pair 2 ^a	Patterns of Selection	43.426	19	12.8024	2.9371
	Pretest				
	Patterns of Selection	79.742	19	10.5304	2.4159
	Posttest				
Pair 3	Speciation Pretest	32.956	18	11.0923	2.6145
	Speciation Posttest	75.222	18	20.8331	4.9104
Pair 4 ^a	Hardy-Weinberg	58.194	18	13.4799	3.1772
	Pretest				
	Hardy-Weinberg	76.494	18	16.0466	3.7822
	Posttest				

^aPLTL Sessions.

be made pertaining to increases in conceptual understanding as a result of PLTL.

Due to the small sample size the interpretation of the results of the quantitative data sets is limited; as shown above, any small changes (i.e., gains in prior knowledge prior to the pretest) drastically altered results of the data sets. Additionally, students performing at a higher level than usual on a pretest could affect their posttest preparations; that is students may be less likely to study for a posttest if they feel confident in the content. Furthermore, the time frame between pre- and posttests was very short, 4–5 days. It was also noted that an anomaly occurred. The last posttest (PLTL session for Hardy-Weinberg subtopic) data gathered showed that some students did more poorly on the posttest than the pretest. This anomaly could be attributed to a variety of factors such as student study habits or exposure to the subtopic prior to pretest or to being unfamiliar or uncomfortable with the peer-led teaching method. All of these factors influenced the overall quantitative data sets.

Research Question 2

The second research question this study addressed was: What are students' attitudes towards the PLTL instructional strategy? Previous research done on PLTL included attitude questionnaires and interviews of PLTL participants. As such, the current research modeled previous studies through developing an attitude questionnaire (see Appendix G) and interview questions (see Appendix H) to gain an understanding of student attitudes towards PLTL. In this section results of the questionnaire responses and interview responses are presented and analyzed.

Attitude Questionnaire

The attitude questionnaire was developed using a five point Likert scale consisting of five statements and one question. Student responses to each question is summarized in Table 3 and analysed to determine student attitudes towards PLTL.

Student comfort level in small groups. Statement 1 asked students to indicate their comfort level discussing classroom topics in small groups during PLTL sessions. Table 3 illustrates student responses to the attitude questionnaire.

As a part of PLTL instruction, students were required to come prepared to class with a question relating to the class topic for that week to discuss with the rest of their group. Whether or not students actively participated in the small group sessions could have strongly depended on their level of comfort interacting with their peers in small groups. Results in Table 3 suggest that 89% of students (strongly agree or agree) felt comfortable discussing topics related to the week's lesson in small groups. Even more surprising, however, was the fact that no student disagreed with the statement, although a small portion (11%) purported being unsure about the situation.

Student understanding of discussion topics. Statement 2 analyzed whether or not students felt that the PLTL sessions helped them to gain a better understanding of the topics being discussed in class. Overall, the majority of the students, 84%, agreed or strongly agreed with the statement, and a small percentage disagreed (11%) or were (5%) unsure about the PLTL sessions.

Small group learning. Statement 3 inquired into students' perceptions of the benefits of continuing with PLTL sessions, that is incorporating PLTL into regular

Table 3

Attitude Questionnaire Responses

Statement	Student responses (%)				
	Strongly disagree	Disagree	Unsure	Agree	Strongly agree
1) I felt comfortable discussing questions relating to the class topic with my peers in small groups.	0	0	11	37	53
2) I felt the discussions in small groups helped me to gain a better understanding of the topic.	0	11	5	42	42
3) I would like to see more small group learning sessions take place in class.	0	5	5	37	53
4) I think having small group learning sessions prior to the final quiz helped me to answer questions on the final quiz.	0	5	5	42	47
5) I think I felt more confident explaining the topics we discussed in small groups to someone else after the session.	0	5	11	47	37

classroom instruction. Students responded quite agreeably to the statement, with a total of 90% agreeing or strongly agreeing with the statement.

Small group learning and performance. Statement 4 asked students about whether or not PLTL sessions helped them to perform better academically. Over 89% of students agreed or strongly agreed with the statement, feeling that the PLTL sessions prior to the posttest helped them to answer questions on the posttest. Although the majority of students did feel the PLTL sessions benefited them academically, 5% of students disagreed with the statement. As noted by one of the interviewees, her mark actually decreased as a result of the PLTL sessions (see Interview Responses section).

Student confidence level. Statement five inquired into whether students' overall confidence in explaining topics discussed in class improved as a result of the PLTL sessions. This statement, in retrospect, may have been difficult for students to interpret because it implied that students discussed topics taught in class and in PLTL sessions with other individuals after the posttest. Whether or not students actually engaged in conversations regarding class topics after the posttest is uncertain. However, the majority of students (84%) agreed or strongly agreed with the statement, although there is a slightly higher proportion, relative to the other statements, of students (11%) who were unsure. Students were not asked if they discussed class topics with peers or adults outside of class time. Despite this, it was noted through personal observation that following the posttest students discussed with their peers what they thought the appropriate answers should be on the posttest, comparing answers with their peers. Overall, students felt confident communicating their scientific knowledge and reported feeling PLTL increased their confidence.

Students' overall experience. Question 6 asked students to rate their overall experience with PLTL. The last question on the questionnaire allowed me to gauge students' overall responses to PLTL sessions. Aligning with what I observed in the classroom, the majority of students (89%) responded positively or very positively to the PLTL sessions. Although some students had vocalized their apprehensions towards its implementation, no student responded negatively to his or her PLTL experience.

Overall, the analysis of interview responses provided data for answering the second research question pertaining to students' attitudes towards PLTL sessions. According to the questionnaire responses, the majority of students had a positive or very positive experience with PLTL sessions. Furthermore, students reported feeling more confident explaining topics, discussing in small groups, and having a greater understanding of scientific concepts.

Interview Responses

Themes were generated from interviewees' responses through reviewing the transcriptions and identifying recurring words, ideas, and phrases within each response. The recurring words, ideas, and thoughts were grouped in order to generate themes. Hence, words that were continually identified within each of the interviewees' responses were categorized into a number of themes (see Table 4).

The 4 students interviewed brought forth their own ideas pertaining to the advantages or the disadvantages of participating in PLTL, which I have categorized into four themes. For each of the four questions represented in the table, each response was grouped according to the four themes represented. The interviewee responses were

Table 4

Qualitative Themes

<i>Question</i>	<i>Help in understanding</i>	<i>Achievement</i>	<i>Group work</i>	<i>Asking questions</i>
1. <i>How did you feel about the peer-led teaching sessions?</i>	<ul style="list-style-type: none"> • helpful • helped me to understand more • helped a little 	<ul style="list-style-type: none"> • improved my marks • wouldn't help marks get higher by a lot 	<ul style="list-style-type: none"> • didn't like to work in groups 	<ul style="list-style-type: none"> • learned more from asking other people • asked leader questions
2. <i>Would you like to see more of these sessions implemented?</i>	<ul style="list-style-type: none"> • helped make people understand more • made us more successful • reviewing before the test helped me • didn't help me • did not help a lot 	<ul style="list-style-type: none"> • brought up my mark • brought my mark down 	<ul style="list-style-type: none"> • good if your group is actually good 	<ul style="list-style-type: none"> • questions were answered
3. <i>Did you learn or gain anything from these sessions? If so, what? If not, why?</i>	<ul style="list-style-type: none"> • very helpful, learned more • I didn't understand and they could help me • helped me remember 		<ul style="list-style-type: none"> • could have learned the same things without being in groups 	<ul style="list-style-type: none"> • answered a lot of questions
4. <i>Are the peer-led teaching sessions different from regular classroom teaching? If so, how? If not, why?</i>	<ul style="list-style-type: none"> • discussing helped me understand 		<ul style="list-style-type: none"> • wouldn't want to ask in front of the class • new to work in groups in a classroom • [didn't like the teacher] not teaching it 	<ul style="list-style-type: none"> • can ask other people questions that you wouldn't want to ask in front of the class • I don't really discuss with other people [normally]

analyzed in relation to the following themes: (a) help in understanding, (b) achievement, (c) group work, and (d) asking questions.

Help in Understanding

For this theme, students' use of the term help as it occurred in student responses to each of the four questions outlined in the interview was analyzed. Help was analyzed in terms of the degree students perceived PLTL as helping them understand evolution concepts. Helping students to understand concepts was one of the primary research questions: What effect does the PLTL instructional strategy have on grade 11 students' conceptual understanding of biology concepts related to the topic of evolution? This question was primarily investigated through pre/posttesting; however, some of the interviewees, without specifically being asked about PLTL improving understanding, made mention of this benefit. The 4 students will be referred to as student one, student two, student three, and student four. Student one, in response to question 1 remarked, "I thought they [PLTL sessions] were really good and helpful . . . and it helped me understand a lot more I didn't understand before." This student felt that participating in PLTL was to his benefit, as he gained a greater understanding of the concepts being discussed in classes. This student further went on to add, "these sessions, they were very helpful and I basically answered a lot of questions you have about the topic and personally I learned a lot more about Darwin . . . the Hardy-Weinberg equations." He felt that it was important and helped him to gain an increased understanding of topics being discussed in class. PLTL had meaning for him because it helped him come to his own personal understanding of the topics being discussed. Student two also felt that the session helped her understanding, primarily through the discussions. She remarked,

“discussing it helped me understand it better.” This student felt that discussions in small groups with her peers helped her have a greater understanding of the scientific concepts discussed. Helping students to further their understanding of scientific concepts requires students to actively participate in PLTL sessions. Students’ overall feelings that the PLTL sessions helped them to gain a better understanding of scientific concepts being discussed in class were reiterated throughout the interview responses.

Despite some of the positive attributes associated with PLTL helping students, student four felt that the “help” was subjective to student experience. Regarding PLTL sessions he noted, “I think it can help, but not a lot ‘cause it basically depends on the individual’s effort.” Student four felt that the sessions benefited students depending on the effort they put into the class, whether studying to prepare for the sessions to test or constructively participating in the sessions.

Student three responded negatively to the sessions, stating that the PLTL sessions “didn’t help me.” Through personal observations, as noted in the observation protocol, group dynamics, which will be discussed in the section entitled group work, may have been one strong contributing factor to her response to PLTL. Many students in the class could share this feeling, as PLTL sessions may not be beneficial to all students. Student attitude and willingness to participate are contributing factors to any of the benefits perceived by students. Student perceptions of PLTL not being beneficial to them will be further explored in subsequent sections.

Student perceptions of “help” regarding PLTL sessions appear to be related to their personal experiences within the PLTL sessions. Interviewees who felt that the sessions developed their understanding of the content also noted that they were answering

questions and discussing with their peers, which play a major role in experiencing positive associations with PLTL. However, as one of the students noted, the perceived benefits are subject to the actual participant engaging actively within the sessions. Overall, these students did feel that the PLTL sessions helped them to gain an increased understanding of the topics being discussed, but the gain was dependent on the individual's level of effort. This finding is supported by the questionnaire results as evidenced in question 3 (see Table 4).

Achievement

The first research question attempted to inquire into whether or not PLTL had any effect on students' academic performance as gauged through pre/posttesting. Students' academic performance (grades/marks) was used to indicate a student's level of understanding of concepts. As such, students reported that beliefs of the effect of PLTL on their achievement (as indicated by marks) is an important aspect to review in terms of advantages and disadvantages of PLTL for students' conceptual understanding.

Student two reported positively about the PLTL sessions and her marks, stating "I felt like it helped bring up my mark." She attributed the increase in her marks to the fact that the PLTL sessions took place right before the posttest, remarking, "reviewing it right before the test helped me." Grades are just as important to students as they are to their teachers. Assisting students to increase their marks had a positive effect on how students viewed the PLTL sessions and how they perceived personal benefits.

A contrary perspective was reported by student three. She felt that the PLTL sessions "only brought [her] mark down." Her lack of enjoyment or willingness to participate in group discussions may have been one of the contributing factors to bringing

her mark down (which will be explored further in the group work section). PLTL adversely affecting students' grades would definitely perpetuate a dislike for the sessions. If the sessions are more of a hindrance than a benefit to student success, the likelihood of willing student participation within the PLTL sessions would be low.

Student four commented that the "peer-led session wouldn't help [him], wouldn't help [his] mark get higher by a lot. Maybe it would help him a little." This was the same student who also commented on the perceived benefits of PLTL as dependent on the individual's effort. Students' grades going higher or lower during the PLTL session may or may not be the result of participating in the PLTL sessions. However, if students have a greater level of participation and felt that the sessions were beneficial to them, this may equate to an increase in grades, while the reverse may be seen in students who felt the sessions were of little benefit to them.

Group Work

Groups are what PLTL is about, peer-led team learning in small groups. How students felt in groups was a major aspect in developing an understanding of PLTL sessions, whether or not students had positive or negative feelings about the group setup.

Student one felt very positive about the groups. He felt that the groups allowed "you [to] ask other people questions that you wouldn't want to ask in front of the class because the other students would answer it without, like, other people commenting on it." Student one suggested that peers, him included, felt more comfortable discussing things they didn't understand with their peers in small groups than they would in class-wide discussions.

Student four also commented on the idea of small group discussion as different from traditional classroom instruction, stating,

It's sort of like new to work in a group in a classroom. Maybe some people work with others outside of the school but, uh, I think it's different, it's the first time I've ever worked in a group in the classroom.

The idea of introducing something that was different from the traditional classroom structure of this classroom allowed some students to engage in a new way. Giving students the opportunity to work in small groups where the learning is facilitated by students may provide an additional outlet for learning, specifically collaborative learning, and taking ownership over information presented to students in class.

Some students, however, may have negative feelings towards group work, as I did as a secondary school student. Student three reported, "I don't like working in groups." Individuals who dislike group work may find it difficult to become actively involved in the PLTL sessions. Their lack of involvement or effort may affect their perceptions of PLTL, and as a result students may find the sessions to be of little value. She further stated, "I could have learned the same things without being in groups."

During observations of the PLTL sessions it was noted that students asking questions and listening to their peers for insightful responses further promoted discussions. In relation to this, the group lead played a major role in facilitating discussions. Although the leads were chosen based on grades, most of the group leads had natural leadership ability and were able to effectively communicate their own understanding of the topic to their peers. As observed in the PLTL sessions, further understanding of topics was facilitated through group discussion, leading not only to the

peer-lead primarily speaking but rather each group member being an active participant in the conversations (witnessed in the majority of groups).

Asking Questions

Working in small peer-led groups is the central premise of PLTL. Within those groups students were asked to discuss, question, and apply what was learned during that week in class. Hence, asking questions is the first step to promoting meaningful and relevant conversations in PLTL groups. Asking questions in the PLTL sessions in this study occurred in three ways: (a) questions asked by peer-leads, (b) questions asked by students, and (c) questions asked by students to the teacher.

In this study, the peer-leads were chosen based on academic performance, which is not an indication of their ability to lead a group. However, all leads, except in one group, exhibited exceptional leadership abilities during the sessions. The role of the peer-leads was to open discussions by reviewing a brief summary they wrote of that week's lesson with the group. Following that, students were asked to share the questions they wrote with the rest of the group. Essentially the peer-leads were a catalyst for promoting discussions among the group members. Student two remarked, "[if] I didn't understand [something] right before the test I could, like, ask the leaders the answer and it was fresh in my mind right before the test." By having the highest marks in class, peer-leads tended to have a good understanding of the content being taught by the teacher. As such, they were able to explain things at the level of a peer to their group members in a way which was relatable to other students. Contrary to this student's experience, however, student three said, "the leaders really didn't do anything . . . people don't take initiative, the leaders." The leaders did have a significant role to play in initiating conversations.

Student three's group was dismantled, and each student was assigned to a different group for the second PLTL sessions because of communication issues within the group.

Although peer-leads were asked to initiate conversation, each group member had an active role to play to continue discussions. Peers were to be interacting with each other, discussing, questioning, and applying their knowledge to real life situations.

Student one stated, "I learned more from asking other people on stuff I wasn't sure of."

PLTL gave students the opportunity to tap into the knowledge of other students, enriching the learners' experience. Furthermore, student two continued on to say,

I gained from these sessions because the specific things I didn't understand they [peers] could help me with, and otherwise we wouldn't really have enough time before the test to, like, go through my notes or ask the teacher all my specific questions for things I didn't understand.

Peers became an additional resource for students. Students were able to ask questions and to collaboratively come up with answers either through discussions or by looking through the textbook for answers (as observed). As student two noted, there was not always time to ask the teacher any last-minute questions prior to the test. Situating the PLTL sessions prior to the posttest gave students the opportunity to discuss with each other potential questions that could come up on the test or concepts they were still struggling to understand.

In terms of asking the teacher, the teacher was still an available resource to students. However, his role, like mine, was to facilitate conversation and to ask questions that would lead students in the right direction in terms of understanding content. Due to the fact that the students usually seek additional direction or clarification from the

teacher, some students may have struggled with the idea of asking their peers for assistance in understanding a concept. This was the case with student three, who stated, “it’s different cause Mr. [T] isn’t teaching it and Mr. [T] actually knows what he is talking about, unlike the students, and ya.” She struggled with discussing with her peers, and whether or not they showed themselves to be incompetent is not known. However, she felt that discussing with them had no value for her. An integral part of PLTL is finding the balance between collaboratively learning as a team and utilizing your outside resources as a team to further engage in discussions, whether it is through the textbook or the teacher.

Interview Synopsis

Through the interviews the following qualitative themes were developed: help in understanding, achievement, group work, and asking questions. These themes were analyzed based on student responses and how and or why they responded to these themes. Overall, students provided very insightful data as to their views of PLTL and its effects on their learning experience in the classroom. Students had positive, neutral, and negative feelings about the sessions and their impact not only on their conceptual understanding but also on their interactions with their peers.

CHAPTER FIVE: SUMMARY, DISCUSSION, AND IMPLICATIONS

The purpose of this study was to investigate the effect of PLTL on secondary school students' conceptual understanding of scientific concepts related to evolution and student attitudes towards its implementation, using a mixed methods approach. Research questions were established to guide the investigation of the study. The two research questions probed the following:

1. What impact does the PLTL instructional strategy have on grade 11 students' conceptual understanding of biology concepts related to the topic of evolution?
2. What are students' attitudes towards the PLTL instructional strategy?

Question 1 was explored through developing pre/posttests that specifically tested for students' conceptual understanding of evolutionary concepts being discussed in class. The pre/posttests identified whether or not there were significant differences between grades of the PLTL sessions and non-PLTL sessions. PLTL was further investigated by developing questionnaires and interview questions that analyzed student attitude towards the sessions. Quantitative and qualitative data were then analyzed independently to develop an understanding of PLTL and its effects on conceptual understanding and student attitudes towards PLTL.

Review of the Study

As a result of PLTL's apparent success in developing student understanding of complex topics in university mathematics and sciences, I developed an altered version of the PLTL sessions for secondary school students. In the current study, PLTL differed from the latter group strategies in some of the following ways: (a) the designated roles of

students—PLTL was characterised by a student peer-lead with student participants and (b) the type of content—students prepared questions on the topic taught.

The current research on PLTL was done on a small scale involving one grade 11 secondary school biology classroom in order to identify whether further large-scale research would be valuable. The same group of students were exposed to the PLTL session who also acted as the control group. This type of study is known as a repeated measures design. This type of design allowed me to develop comparisons for students between non-PLTL and PLTL classroom practices for this particular teacher. Using the same group of students had advantages and disadvantages. Advantages included gaining a perspective on differences in student attitudes towards change in their normal learning routines. Disadvantages included the small number of students for data collection of pre/posttests.

Quantitative analysis of the first research question regarding the impact of PLTL on students' conceptual understanding of evolution concepts was done through comparing pre/posttest scores. Results showed a significant difference in means when comparing pre- and posttests for each subtopic. The significant difference in pre- and posttest scores suggests gains in conceptual understanding for both PLTL and non-PLTL sessions. In order to make statements regarding the PLTL intervention and conceptual understanding, a paired samples *t* test to compare pretest means was initially performed. However, when comparing means between pretest scores, it was evident that methodological errors led to inconsistencies among the pretest mean scores. As a result, comparing posttest means through a paired samples *t* test was not done.

Possible factors that led to methodological errors include (a) gains in student knowledge due to exposure to the subtopic prior to the pretest, (b) inconsistencies in instructions given to the students for each pre- and posttest and between subtopics, and (c) small sample size. Consequently, no conclusive evidence was gathered through inferential statistics to claim or disclaim the impact of PLTL on students' conceptual understanding of evolution concepts using quantitative analysis.

Qualitative data collection methods were developed by drawing on previously done PLTL studies and included questionnaires and interviews. In the current study, students were asked at the conclusion of the last posttest to fill out a questionnaire in order to gauge overall attitudes towards different aspects of PLTL. In addition to the questionnaire, 4 students (2 male and 2 female) were interviewed based on their responses (positive or negative) on the questionnaires. These students provided further insight into some student attitudes towards PLTL. These data sets, questionnaire, and interview responses, were further triangulated through classroom observations recorded as field notes during the PLTL sessions. As well, students' artefacts such as the questions and responses used during PLTL discussion periods were collected.

The qualitative data included a classroom observation protocol, the attitude questionnaire, and interview questions. All of these data sets reinforced each other in terms of developing overlapping themes between the data sets. The four major themes that emerged in the study were help in understanding, asking questions, achievement, and group work.

Help in understanding was a recurring theme. Reviewing the interviewee responses showed that students in general felt that the PLTL sessions were helpful,

helping them to have increased understanding of scientific concepts. Questionnaire statement 4 reinforces this; students felt that having discussions about class topics prior to the posttest helped them.

Asking questions also played a major role in developing student understanding. Students asking their peers questions prior to the final posttest may have influenced their performance on the posttest. This was supported by interviewee responses suggesting that peers, peer-leads, and the teacher were all important resources to be utilized during PLTL sessions.

Students also suggested that PLTL influenced their achievement scores. Responses to questionnaire statement 3 and question 6 suggested students would want to see more PLTL sessions implemented and overall they had a positive experience with PLTL. This may have been due to some students reporting in interviews increased marks, development of collaborative discussions in small groups, and their enhanced ability to use classroom resources that go beyond the teacher and textbook.

In regards to group work, the majority of student responses on the questionnaire suggested a strong positive feeling towards PLTL and small group learning. Group work was perceived as a very positive experience that benefited the majority of students.

In response to the second research question, interviewees, questionnaire responses, and observed student interactions all supported the idea that students overall had positive attitudes towards PLTL and its implementation in regular classroom instruction.

Quantitative and qualitative data were analyzed independently; however, overlapping conclusions were drawn through comparing research findings. The main

findings and their implications will be discussed in greater detail in the following sections: (a) discussion, (b) implications, and (c) conclusion.

Discussion

The following section will critically reflect on the quantitative results of the study. This includes comparisons to previous studies and the qualitative aspects of the study including previous studies that relate.

Quantitative Results

Quantitative analysis of PLTL included pre/posttesting, which was done in order to compare means of pre/posttest as well as comparing the means between posttests. The discussion will highlight issues affecting the graphical/statistical analysis, quantitative limitations, and pertinent results from previous studies.

Issues Affecting Interpretation of Results

Comparing means between pre- and posttests via paired samples *t* test identified a significant difference between scores, suggesting students performed better on posttests than pretests, representing gains in conceptual understanding. Additionally, for each pre- and posttest the means were compared graphically to show differences between prescores and postscores per subtopic. Data results show that some pretest scores were higher for some subtopics than others.

One of the issues that presented with pre/posttesting was controlling what evolutionary content students were exposed to prior to the pretest. The pretest gauged students' knowledge base prior to teaching (which was affected as a result of subtopics being taught prematurely). For example, the second scheduled subtopic pretest was changed due to the teacher teaching the topic prior to the pretest. This resulted in overlap

of content between subtopics, which may explain why some pretest scores were higher than others. Hence, students' knowledge base on that topic would be greater. As a result of a higher pretest score, or students feeling they understood the content, they may have put little effort into reviewing for the posttest, which could be the case for the Hardy-Weinberg subtopic which had a lower posttest score than expected, since it did have the highest pretest score.

The Hardy-Weinberg subtopic replaced the Natural Selection subtopic as it was taught prior to the pretest (see Chapter Three). This subtopic was suggested by the teacher. However, during the Speciation subtopic classroom observation, I noted that the teacher began to teach the fundamentals of Hardy-Weinberg equations within the Speciation subtopic. Consequently, students were exposed to Hardy-Weinberg content prior to the pretest, resulting in higher pretest scores.

Similarities in scores between the PLTL session for Patterns of Selection and the non-PLTL session of Speciation for both subtopics may have been due to students having a greater length of independent work periods for the subtopics to work through questions and examples in the textbook. All of the subtopics the teacher taught, excluding History of Evolution, allowed for the teacher to include multiple examples and questions to review as a class in addition to independent work periods. Students having a greater period of time to go over examples, review notes, and read the textbook may have contributed to consistently higher posttest scores for all of the subtopics following the History of Evolution subtopic. The difference in mean scores for these tests may be due to students' exposure time to the content being learned; the Speciation subtopic was a much longer taught subtopic than the History of Evolution. During the teaching of

Speciation, multiple examples were used and time was given to work on questions relating to the topic in class, which was not the case for the History of Evolution subtopic. The length of time that students got to work in class on questions relating to a topic could account for differences in mean scores between the non-PLTL and PLTL sessions. Hence, no conclusions regarding PLTL and its effects on conceptual understanding as it relates to an increase in academic performance can be made due to statistical differences between mean scores for non-PLTL and PLTL sessions. Overall, no significant claims about the effects of PLTL on students' conceptual understanding can be made.

Limitations

Test results in general were difficult to interpret due to a number of limiting factors which included class size, the inability to control student exposure to concepts prior to the pretest, and the short time period between pre/posttests. A small sample size limited the data set; as a result, inconsistencies in student performance significantly altered findings. Exposure to a subtopic prior to a pretest influenced pretest scores, making it difficult to compare to posttest scores. Students performing at a higher level than usual on a pretest could affect their posttest preparations (i.e., students may be less likely to study for a posttest if they feel confident in the content). Consequently, students may try to remember what they think the correct answer on the test may be rather than actually working through the question as it is presented. All of these factors present issues pertaining to interpreting result findings and developing meaningful conclusions. Hence, the current research results are difficult to compare with previous studies done using similar methodologies because of the issues aforementioned.

Comparisons to Previous Studies

Despite difficulties in interpreting quantitative results, reviewing findings from similar studies can provide insight as to whether or not continued research on PLTL within secondary schools is warranted. Quitadamo et al. (2009) implemented PLTL for undergraduate science students. They determined through their quantitative analysis that PLTL students demonstrated 9 times greater gains than non-PLTL students in science “[It] had a practical influence on critical thinking gains (p. 36) [and] . . . accounted for 1.6% of variance in critical thinking gains” (p. 34). Critical thinking gains can parallel gains in conceptual understanding (conceptual understanding requires developing higher cognitive skills). Although the current study does not have data to support this idea, previous studies do speak of the benefits of PLTL with supporting quantitative data. The study done by Tien et al. (2002) implementing PLTL sessions as an undergraduate workshop found, that ANOVA results confirmed that the PLTL groups significantly impacted the performance of students. Their study demonstrated that “workshop [PLTL] students earned an average grade of B/B-, whereas control students earned an average grade of B-/C+” (pp. 615–616). In the current study, quantitative analysis was limited due to the group size, the duration of PLTL sessions, and extraneous factors that were not controlled for in this study which included assessing group dynamics (discussed in the qualitative section). Developing a similar study investigating the effects of PLTL on academic performance on a larger scale setting over a longer period of time could minimize inconsistencies related to student performance.

Student Attitudes and PLTL

Although similar quantitative results were not replicated within the current study, qualitative results support further implementation of PLTL. The qualitative data sets investigated student attitudes towards PLTL. Results identified in Chapter Four outline a number of characteristics that were commonly mentioned by students including the aspect of help in understanding, achievement, group work, and asking questions. Overall, students' attitudes towards PLTL were positive. However, group dynamics appeared to play a critical role in collaborative learning; discussing, questioning, and applying of scientific concepts would be difficult to take place cohesively if group interactions were not positive. Consequently, the following section will discuss qualitative results in terms of group dynamics, student attitudes, and previous studies.

Group Dynamics

Group work can be challenging, as students may not be able to identify with each other or communicate effectively. In this study, group dynamics played a critical role in PLTL sessions being meaningful to students. Through doing the research it was noted that important aspects of group work to consider when implementing PLTL are students' willingness to take risks, ask questions, listen to each other, and develop a sense of trust within their group. Group dynamics thus requires examining the role of the group lead, students' comfort level in groups, and quality of discussions. While the results of the quantitative analysis suggest that the majority of the students in this secondary science classroom felt that the PLTL sessions helped them understand the subtopics taught in class and indicated their preference for more small group sessions, the qualitative results

support and contribute to literature on small group learning in education by highlighting issues related to group dynamics that affected the quality of PLTL sessions.

One of the reasons for implementing PLTL sessions was to allow students the opportunity to share their knowledge/understanding of topics with their peers and simultaneously develop their own personal understanding of the topic. The intent was for students to go beyond the typical independent learning that usually takes place in secondary classrooms. Fear of ridicule is one of the reasons why some students are unwilling to ask questions in front of the entire class. PLTL reduces some of that anxiety by allowing students to discuss in small groups of five to six students. In this study, students were challenged to go beyond what was presented to them by the teacher and in the textbook and were involved in actively participating in the PLTL sessions.

One group had very little active discussion taking place pertaining to the class topic. This group was disbanded for the second PLTL session due to the lack of productivity. It was noted that after changing the groups, students seemed a bit more distracted during their last PLTL session than in their first as a result of adding some new people to the groups. This may have changed the group dynamics, resulting in less cohesion than experienced during the first PLTL session. If students are having their own private conversations and not discussing collaboratively, as was the case in the disbanded group, students will not have a positive experience with the PLTL sessions. Consequently, some students' negative feelings towards sessions may be due to a lack of engagement within their groups. If students feel like they were not being challenged or learning more in the PLTL groups, then students do not see the value in the PLTL session.

Comfort level plays a large role in the level of student participation within the PLTL sessions. Collaboratively discussing, questioning, and applying what was taught in class could not have taken place in the small group settings without a certain level of comfort being established. As recorded in the observation protocol, students displayed varying degrees of comfort; some students were more vocal than others, and some tended to be better listeners. Having different roles among the groups was another important aspect. If all students wanted to be the lead or were always talking and no listening took place, the purpose of the PLTL sessions could not be accomplished. Despite the varying ranges of vocalization during the PLTL sessions, overall, students appeared to be quite comfortable in small peer groups.

What the students in each group were discussing is another important factor affecting PLTL sessions. Some of the students' questions and answers discussed during PLTL sessions were reflective of questions presented on the pre/posttests. When students discuss problems and solutions to questions on the test, they may be more prepared to do well on the tests.

Group dynamics is an important factor to consider when analyzing the results, as some groups were more productive and focused in their discussions than others. Hence, future research into PLTL should take into consideration how students interact with their peers, comfort level, and level of productive discussions taking place, when controlling for variations in group dynamics.

Student Attitude Towards PLTL

The second research question assessed students' attitudes towards PLTL primarily through the questionnaires and interviews. Students in response to interview and

questionnaire questions said they desired more PLTL sessions within the classroom. These results may be due to the high proportion of students who felt that the discussions helped give them a better understanding of the topic being discussed (see Table 5). If students felt they were gaining from small group discussion periods with their peers, the idea of continued sessions may be to their benefit. During one of the non-PLTL sessions a student commented as to why they were not having the PLTL session that week. She continued on to explain that she really enjoyed the session and felt she understood more prior to the posttest (as recorded through the observation protocol). However, some of the students may have disagreed with the statement due to not having had a positive experience with PLTL groups, which may have been attributed to a number of factors previously discussed in the group dynamics section.

Such a positive response experienced by students suggests that further research into the implementation of small group peer-led learning sessions like PLTL should be conducted in order to get a broader spectrum of its effects on students' conceptual understanding and attitudes towards PLTL. It was observed that many students had very positive attitudes during the PLTL sessions, engaging in conversation and attempting to be active participants within the conversations related to classroom learning. Students seemed to have been developing their active listening skills as they allowed their peers the opportunity to speak without disruptions. Overall, I witnessed students working collaboratively to enhance each other's understanding through discussing, writing answers down to questions, and drawing diagrams (evidenced in collection of students' written questions and answers collected). Students were engaged, actively creating their own personal learning experience that was meaningful to them.

Furthermore, interviewees noted the importance of academic achievement in the continued implementation of PLTL sessions, as marks are a critical component used to analyze the level of student success in courses. If students feel that the PLTL sessions are to their academic benefit, the continued implementation of the sessions may be a positive addition to traditional classroom environments. Conversely, if students perceive the PLTL sessions as negatively impacting their academic performance, their continued implementation could create resistance to its implementation within the usual classroom structure.

PLTL sessions were designed to make the student become an active participant in his/her own learning experience. Rather than have the traditional teacher-centred learning, whereby students listen, take notes, and read the text, the PLTL strategy places students at the centre of their learning and students take control of how they are learning. Students who do not take active roles in the PLTL sessions through asking questions, discussing with their peers, and applying what was learned in class to relevant situations will not benefit greatly from the sessions. Realistically, the help that PLTL provides is accomplished only through students taking an active role in their own learning experience.

Overall students' attitudes towards PLTL varied based on their personal experiences pertaining to the amount of perceived help in understanding, achievement, group work, and how asking questions affected them. Positive or negative experiences in these areas can create the acceptance or rejection of the continued implementation of PLTL sessions.

Previous Studies

The results of the current study indicate that students had a positive attitude towards PLTL and furthermore interviewees also reported positive gains in terms of understanding content and academic performance. Despite the lack of conclusive quantitative results to support the continued investigation of PLTL in the classroom, the qualitative results provide insight into some of the perceived benefits. Students reported that they found the session to be helpful for understanding scientific concepts in their interview and questionnaire responses, which supports the findings of Tien et al.'s (2002) study. Their PLTL workshop study, as mentioned, found that students thought “workshops helped them learn organic chemistry; they found it socially engaging, intellectually stimulating, and above all a productive use of their time” (pp. 613–614). Other findings similar to Tien et al.'s findings are students reporting having a positive experience, feeling comfortable discussing with their peers, and understanding concepts more through discussing with their peers.

Time as a factor was not addressed in this study because students participated in PLTL as part of regular classroom instruction rather than outside class time, as was the case in the Tien et al. study. Additionally, Tien et al. and Micari et al. (2006) reported students having positive meaningful experiences with PLTL whereby students were able to “consolidate knowledge, enhancing conceptual understanding, and developing problem solving skills” (p. 288). These previous studies corroborate results of the current study's qualitative findings of students' perceived benefits pertaining to increased conceptual understanding, positive attitudes, and additional learning benefits as a result of the PLTL experience.

Implications

The literature review indicates that PLTL has not been implemented within secondary schools or little research has been done in this area; as such the current study contributes new knowledge to the literature on teaching and learning science in secondary schools. Findings of the current study suggest that students found that PLTL sessions (a) were engaging, (b) were an interactive form of learning with peers, and (c) supported their understanding of new concepts. This new knowledge has implications for students, educators, educational literature, and future research.

Students

Upon completion of PLTL sessions, many of the secondary school participants in the study were very positive regarding PLTL sessions. The implementation of PLTL sessions provided students with an additional learning resource. Traditionally, students ask the teacher questions or students may look in their textbook when they are unsure about a topic or require further insight to understand what they are learning. Students reported that their peers, through small group discussions, became an additional learning resource. Working with peers encouraged students to be more interdependent, resourceful, and confident in their abilities to gain an understanding of concepts. PLTL provided a means for differentiating instruction where this learning strategy effectively met the needs of learners who enjoy learning in small groups.

Additionally, PLTL, as a learner-centred strategy, may motivate learners and increase their interest in the topic and contribute to learners' preparedness for and participation in science careers. It may also play a role in supporting nonscience careers by providing lifelong skills such as oral communication and decision-making skills.

Furthermore, student-centred learning gives students the opportunity to take responsibility for their own learning successes and failures as a result of their individual effort into understanding what is being taught to them. This relates to current assessment standards in school which include “assessment *as* learning” whereby “students [are] active critical thinkers [who] make sense of information, relate it to prior knowledge and use it for learning” (Earl, 2006, p. 7). Future implementation of PLTL within the secondary science classroom could result in gains for students in their cognitive development in terms of their conceptual understanding, ability to communicate their knowledge to those around them, and scientific literacy.

Teachers and School Boards

The findings will be of interest to teachers as they provide an example of an instructional strategy that could be implemented in their classrooms and easily ties in with “assessment *as* learning,” helping students to become critical thinkers (Earl, 2006). The findings provide school boards with current educational research that could be used to inform staff members about a learning strategy which supplemented classroom instruction. PLTL could be further implemented within various academic subjects outside of biology.

Furthermore, research pertaining to improving students’ conceptual understanding provides insight into new teaching pedagogies, teaching pedagogies which relate to developing scientific literacy. As Hodson (2003) and Osborne (2002) note, integral to scientific literacy is students being active participants in their learning. PLTL provides opportunities to further enrich scientific literacy through students collaboratively working in small groups to discuss, question, and apply their knowledge pertaining to that week’s

lesson. PLTL is an additional strategy which provides diversified learning experiences based on the results of the current study and previous studies. Hence, for teachers, it provides an additional student-centred pedagogy upon which to draw.

The setting up of PLTL sessions as described in this thesis can be used as a resource by teachers and school boards for classroom implementation in secondary schools. Implementing PLTL adds pedagogical diversity within the typical secondary class lesson which could lead to increased student engagement and participation within lessons. The traditional pedagogies tend to have students primarily listen, with little time given to consolidating knowledge through peer discussions. However, PLTL provides an additional learning strategy, with students as active participants. Educators, rather than consistently being the primary source for answers, can become a supplemental resource for learning. Educators become facilitators of learning, guiding students to ask the right questions and to think and discuss what they may or may not understand by drawing on prior knowledge and experience. This perspective of learning is consistent with constructivist perspectives of learning. Rather than students asking for the answers from their teachers, students are asked to think through problems to come up with answers through discussion with their peers. As students take on more active roles in their learning, teachers can begin to challenge students to go beyond their usual level of engagement and academic performance.

Educational Literature

The current study provided the framework for future research in the area of PLTL for secondary school students, particularly in the sciences. Results identified that students had positive attitudes towards PLTL and its implementation. However, the quantitative

data supporting the idea of improved conceptual understanding was insufficient in order to make claims. Consequently, future researchers can develop larger scale studies of PLTL based on this current smaller scale study, taking into account some factors mentioned that limited the findings. Despite limitations, the educational literature will benefit from gaining an understanding of how PLTL affects students' work ethic and their ability to learn in small peer-led group settings. The positive experiences of the students suggest that further research in this area would provide insights into the benefits of integrating learning strategies like PLTL into everyday classroom practices in secondary schools.

Additionally, a goal of science education is to develop scientific literacy (Hodson, 1998; Murcia, 2009; Ontario Ministry of Education, 2008). Communication skills such as reading, questioning, and arguing promote scientific literacy (Duschl, 2008; Osborne, 2002). In this study, PLTL was characterised by students developing questions about a particular science topic and discussing with peers how they could understand more about it. The latter involved applying what they learned and learning how it related to real-life situations. PLTL, with its emphasis on using oral communication skills to develop conceptual understanding, contributes to the development of scientific literacy.

Considerations for Future Research

Considerations for future research involve looking at factors that should be addressed in future research. The factors addressed in this study include the timelines and the role of students.

Timelines

One issue that is debatable is the amount of preparation time required to implement the PLTL sessions. Sessions required planning, preparation, and organization on the part of the teacher and students. The undergraduate study done by Micari et al. (2006) required peer-leaders to be trained and to have previously taken the course. Peer-leads were given specific directions to facilitate the sessions. However, in the current study, being that the research took place within a secondary school, the class size, and hence the sessions, were not on the same scale as reviewed in previously done studies. Consequently, the main issue of time to be addressed within secondary schools was the duration of the sessions. Within previously done studies, PLTL sessions took place outside of class time; thus, no teaching time was eliminated as a result of the program. Conversely, allotting a separate time for students to meet within a moderately sized secondary school was not the most viable option.

First, due to the introduction of the program, many students may not have seen the value in participating in academic-related studies outside of class time. Second, within this particular secondary school only, one grade 11 biology class was taught; hence, designating a separate time period outside of class time would have been more time-consuming. In this study it was more feasible to allot a period of the teaching or a work period time of the students to PLTL sessions, as the teacher usually allotted work periods for students to independently review prior to a test. Since students are usually not lectured to for the duration of the class, the introduction of PLTL sessions did not cause significant disruptions to traditional classroom practices or take up allotted teaching time. This may be one practical strategy to incorporate PLTL into regular classroom practice.

Planning the allotted time for the small group sessions was an important aspect to maximize discussion periods and minimize conversations that were irrelevant to that day's topic. Both planning and preparation required a tremendous amount of organizational skills in order to see the successful implementation of PLTL groups. The sessions were organized in such a way that students were aware of their role and the purpose of the sessions. Planning ensures that specific periods of time were designated for reviewing, questioning, and applying what had been learned in the form of discussion of specific application questions students generated. Outlining the framework for these sessions played an integral role in the successful execution and enriched learning experience that students gained.

Role of Students

In addition to the aspect of time management, students themselves could have become an obstacle to implementing the learning sessions. Part of the reason implementing such strategies can be challenging is the fact that they are student-focused; although a challenge, the student-focused nature is also part of the reason for the success of PLTL. Students actively take on responsibility for their success or lack thereof as a result of their own efforts. Although it is initially challenging to help students understand the importance of their role in the group, placing greater ownership on the learner creates greater rewards as students realize their success is based on their efforts, independently and collaboratively. Earl (2006) asserts that “[students] learn best in groups, as they listen to one another, strive for agreement and rethink their beliefs and understanding” (p. 5). PLTL provides opportunities for the learner to grow and develop these skill sets. When students are more attuned to the gains they can achieve through being actively involved

in the learning process, the challenges that were presented when initially starting the sessions seem mundane relative to the overall achievement advances students experienced.

In order to achieve success, students were prepared to participate in sessions. As such, students within small groups needed to be aware of their role in the group. Whether they were peer-lead or played some other significant role, students needed to be aware of their responsibilities. Hence, prior to the commencement of sessions, each student was assigned roles within their small group. Whether a student was the lead (briefly reviewing the day's lesson) or bringing forth questions for the group to discuss, each individual participating played a significant role. Allowing students to be teachers to one another provided an opportunity for cognitive advancement. Placing students in positions where they must generate conversation in order to learn something meaningful created the potential for improved understanding through peer-led scientific discussions.

Conclusions

The purpose of this study was to investigate the impact of PLTL on secondary school students' conceptual understanding of scientific concepts through pre/posttesting and assessing student attitudes towards the intervention via questionnaires and interviews. Results pertaining to conceptual understanding as assessed through pre/posttesting were inconclusive; however, questionnaire and interviewee responses suggested improved conceptual understanding as well as positive attitudes towards PLTL. As such, future research focusing on improving students' conceptual understanding through learning strategies like PLTL would provide greater insight into

such learning strategies for enhanced student understanding. Dewey (1944) clearly articulates the premise underlying PLTL and the insight it can provide to learners:

It is that no thought, no idea, can possibly be conveyed as an idea from one person to another. When it is told, it is, to the one whom it is told, another given fact, not an idea . . . but what he directly gets cannot be an idea. Only by wrestling with conditions of the problem first hand, seeking and finding his way out, does he think. (pp. 159–160)

PLTL is student-centred learning. Students take initiative, responsibility, and empower themselves to become independent thinkers through collaboratively working with their peers to discuss ideas, ask questions, and apply their knowledge in new ways.

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Appendix A

Brock Research Ethics Board Clearance



**Brock
University**

Office of Research Services
Research Ethics Office

St. Catharines, Ontario, Canada L2S 3A1
T: 905-688-5550, Ext. 3035/4876 F: 905-688-0748

www.brocku.ca

DATE: 12/7/2009

FROM: Michelle McGinn, Chair
Research Ethics Board (REB)

TO: Kamini Jaipal Jamani, Education
Thadeane Wells

FILE: 09-013
Masters Thesis/Project

TITLE: Peer-Led Teaching as an Instructional Strategy in High School Science

The Brock University Research Ethics Board has reviewed the above research proposal.

DECISION: Accepted with notes

- Please remove the first sentence of the "what's involved" section of the consent form as it confuses the study with the curriculum.
- Your consent form states data from students who withdraw will be kept until the study has been published. Your application states that it will be destroyed. Please be consistent. Destruction of data upon withdrawal is the norm.
- Please forward revised consent material.

This project received ethics clearance on December 7, 2009. The clearance period may be extended upon request. ***The study may now proceed.***

Please note that the Research Ethics Board (REB) requires that you adhere to the protocol as last reviewed and cleared by the REB. During the course of research no deviations from, or changes to, the protocol, recruitment, or consent form may be initiated without prior written clearance from the REB. The Board must provide clearance for any modifications before they can be implemented. If you wish to modify your research project, please refer to <http://www.brocku.ca/research/policies-and-forms/forms> to complete the appropriate form Revision or Modification to an Ongoing Application.

Adverse or unexpected events must be reported to the REB as soon as possible with an indication of how these events affect, in the view of the Principal Investigator, the safety of the participants and the continuation of the protocol.

If research participants are in the care of a health facility, at a school, or other institution or community organization, it is the responsibility of the Principal Investigator to ensure that the ethical guidelines and clearance of those facilities or institutions are obtained and filed with the REB prior to the initiation of any research protocols.

The Tri-Council Policy Statement requires that ongoing research be monitored. A Final Report is required for all projects upon completion of the project. Researchers with projects lasting more than one year are required to submit a Continuing Review Report annually. The Office of Research Services will contact you when this form *Continuing Review/Final Report* is required.

Please quote your REB file number on all future correspondence.

MM/mb

Appendix B

History/Attitude Questionnaire Towards Science

- 1.) Have you previously taken this course? YES/NO
- 2.) Have you previously been tutored and or a taken summer course in science? YES
– when? _____/NO
- 3.) I feel I understand science concepts well. (1 – strongly disagree, 2 – disagree, 3 –
unsure, 4 – agree, 5 – strongly agree)
- 1 2 3 4 5
- 4.) I think learning science is relevant to my future. (1 – strongly disagree, 2 –
disagree, 3 – unsure, 4 – agree, 5 – strongly agree)
- 1 2 3 4 5
- 5.) I would like to pursue a career in science. (1 – strongly disagree, 2 – disagree, 3 –
unsure, 4 – agree, 5 – strongly agree)
- 1 2 3 4 5

Appendix C

History of Evolution Test

Modified True/False: Categorize each sentence as either true or false. **If false,** change the italicized word to make the sentence true (**1 mark each**)

1. _____ *Adaptation* is an inherited characteristic that improves an organism's ability to survive and reproduce over time. _____ (T)
2. _____ Hummingbirds and butterflies both have wings. This is considered to be an example of *homologous* structures. _____ (F-analogous)
3. _____ A set of statements that explains a group of facts or phenomena is known as a *hypothesis*. _____ (F-theory)
4. _____ The most desirable adaptations are those that give an organism a *survival advantage*. _____ (T)
5. _____ Hutton proposed that rock formations are continually being formed. His evidence supported *Cuvier's* theory of uniformitarianism. _____ (F-Lyell)
6. _____ *Evolution* is defined as the change in the characteristics that are the most common in the population. _____ (T)
7. _____ The most impressive direct evidence of evolution comes from the study of the *fossil record*. _____ (T)

Matching: Match the numbers from the left column with the letters from the right column (**1 mark each**)

Left	Right
8. Hips found in whales are _____ to the functioning hips in other animals. (homologous)	A. actualism
9. Using carbon to determine the age of organic material is an example of _____ (radiometric dating)	B. artificial feature
10. The half-life is a measure of _____ (radioactive decay) of a parent isotope into a daughter isotope.	C. homologous
11. Periods in fossil records marked by a burst of new species followed by	D. Lyell
	E. Malthus
	F. punctuated equilibrium
	G. radioactive decay
	H. radiometric dating

lack of changes could be explained by the theory of _____ (punctuated equilibrium)	
12. His theory helped Darwin understand population changes and their effect on survival _____. (Malthus)	

Short Answer:

During his ventures to the Galapagos Islands, Darwin noted variations within finches' beaks. How did Lamarck's theory help Darwin to understand what was happening on the islands and also help him develop his own theory? **(3 marks)**

Lamarck's theory of adaptation suggested that creatures adapt to their own environments. Darwin noticed these same adaptations within the finches. Depending on the food they ate, their beaks were suited to that function. These observations helped Darwin develop his theory of natural selection.

Appendix D

Patterns of Selection Test

Modified True/False: Categorize each sentence as either true or false. **If false**, change the italicized word to make the sentence true. (1 mark each)

1. ____ The allele for sickle-cell anemia differs from the normal hemoglobin gene by having a single base pair mutation. _____ (T)
2. ____ Harmful mutations occur frequently but they are selected against; therefore, these mutant alleles are extremely *common*. _____ (F-rare)
3. ____ Individuals carrying the allele for sickle-cell anemia are *mildly* affected by sickle-cell anemia but are much more resistant to malaria. _____ (T)
4. ____ Homozygous individuals of sickle-cell anemia are *severely* afflicted with the disorder. _____ (T)
5. ____ Beneficial mutations are *rare* but they are selected for; therefore, these mutant alleles accumulate over time. _____ (T)
6. ____ Heterozygous individuals of sickle-cell anemia are *weakly* favoured in regions where malaria is common. _____ (F-strongly)

Matching: Match the numbers from the left column with the letters from the right column (1 mark each)

Left	Right
7. Medium bill length is the most common phenotype in a population of hummingbirds. This is an example of _____ (stabilizing selection)	A. cumulative selection
8. Birds' bills and tongues that are most adapted to the size of the flowers they feed on are most _____ by the environment. (favoured)	B. directional selection
9. The short bill and longer bills of hummingbirds are most favoured in an environment which favours either extreme trait. This is known as _____ (disruptive selection)	C. disruptive selection
10. The decrease in long length flowers would result in an increase in a specific phenotype of hummingbirds which is characterized as _____ (directional selection)	D. evolutionary
11. Disruptive selection is a/an _____ mechanism for distinctive forms within a population. (evolutionary)	E. favoured
	F. observable
	G. sexual selection
	H. stabilizing selection

12. Male peacocks displaying their bright plumage could attract predators; however, _____ favours traits that influence mating success. (sexual selection)	
---	--

Short Answer:

Explain how cumulative selection provides a scenario for the evolution of the eye from an organism which has developed a patch of photosensitive cells, to the formation of a crude lens. Explain how these changes would benefit the organism. **(3 marks)**

After millions of years with photosensitive skin cells a mutation could occur which could allow the light sensitive cells to form a pit; this pitted area of light sensitive cells could allow the organism to sense the direction of light. Another mutation could result which exaggerated the pit, resulting in increased directionality of light. As small changes continue to occur the pit becomes so exaggerated as to form a pinhole eye. Over time the material within the pit could accumulate and harden resulting in the formation of a crude lens. This increased light sensitivity would allow these mutations to persist in the organism.

Appendix E

Speciation Test

Modified True/False: Categorize each sentence as either true or false. **If false**, change the italicized word to make the sentence true. (1 mark each)

1. ____ Evolutionary change that occurs at the species level is refereed to as *macroevolution*. ____ (F–microevolution)
2. ____ *Speciation* is the formation of entirely new species. ____ (T)
3. ____ Species can be distinguished by a *palaeobiologists* comparing morphological features using the fossil record. ____ (T)
4. ____ Two species of tree frogs cannot be differentiated by their appearance but rather through the sound of their mating calls; this is an example of *temporal isolation*. ____ (F–reproductive isolation)
5. ____ The offspring of genetically dissimilar parents are known as *crossbreeds*. ____ (F–hybrids)
6. ____ Two species of stickleback that occupy different habitats of the same lake may have resulted from *allopatric speciation*. ____ (F–sympatric speciation)

Matching: Describe the reproductive isolating mechanism operating in each situation by matching the numbers from the left column with the letters from the right column. (1 mark)

Left	Right
7. Some organisms release their sperm into open waters. The sperm and eggs rely on molecular markers to recognize one another to prevent fertilization with a different species. This is known as _____. (gametic isolation)	A. behavioural isolation B. ecological isolation C. gametic isolation D. hybrid infertility E. hybrid inviability F. mechanical isolation G. temporal isolation H. zygotic mortality
8. An experiment fails when a fish breeder tries to fertilize trout eggs with salmon milt. A few eggs hatch, but the fry lack vigour and many are deformed. This is an example of _____. (hybrid inviability)	
9. A liger (offspring of a male lion and female tiger) unable to reproduce offspring is an example of _____. (hybrid infertility)	
10. Ground squirrel species inhabiting different habitats is an example of _____. (ecological isolation)	

<p>11. Structural differences in reproductive organs which can prevent copulation is known as _____. (mechanical isolation)</p> <p>12. The elaborate dance of jumping spiders that attracts certain female spiders is an example of _____. (behavioural isolation)</p>	
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Short Answer:

Name and discuss what mechanism of speciation occurred between the finches of the Galapagos Islands versus the finches of the mainland of South America. **(3 marks)**

Allopatric speciation occurred between the finches on the island versus the mainland. The birds were separated by an ocean (geographic barrier); as a result, the species evolved to suit their current habitats. No allele exchanging occurring between the two populations resulted in two populations diverging to form a new species.

Appendix F

Hardy-Weinberg Test

Modified True/False: Categorize each sentence as either true or false. **If false**, change the italicized word to make the sentence true. (1 mark each)

1. ____ Individuals who possess different alleles for the same gene are *homozygous* for the trait. ____ (F-heterozygous)
2. ____ The *allelic frequency* is the total of all the alleles in the population. ____ (F-gene pool)
3. ____ A population consisting entirely of homozygous individuals for the same phenotype is described as having a *fixed* allelic frequency. ____ (T)
4. ____ For species like the Whooping Crane that has a very small population size, this population could have been said to have *met* at least one of the Hardy-Weinberg conditions. ____ (F-not met)
5. ____ The proportion of gene copies in a population of a given allele is the *genotypic* frequency. ____ (F-allelic frequency)
6. ____ *Genetic mutations* change the frequencies of new and original alleles. ____ (T).

Matching: Match the numbers from the left column with the letters from the right column (1 mark each)

Left	Right
7. In the Hardy-Weinberg equation $p^2 + 2pq + q^2 = 1$, the number given by $2pq$ represents the total number of _____ within the population. (heterozygous individuals)	A. allelic frequency B. genetic drift C. gene pool D. genotypic frequency
8. Chance changes in allele frequency occurring in a small population of frogs is an example of _____. (genetic drift)	E. Hardy-Weinberg F. harmful mutation G. heterozygous individuals
9. A species of moth have 500 AA, 250 Aa, and 125 aa individuals within their population; this equates to a(n) _____ of $A = 0.714$ and $a = 0.286$. (allelic frequency)	H. homozygous dominant individuals I. neutral mutation
10. _____ has no immediate effect on an individual's reproductive success. (neutral mutation)	

11. A species of bird is composed of 750 distinct individuals and a total of 1500 alleles. These alleles are known as the bird population's entire _____. (gene pool)

12. The _____ principle helps to identify important factors that can cause evolution. (Hardy-Weinberg)

Short Answer:

A large population of moths consist of 600 individuals, of which 443 are homozygous dominant, 144 are heterozygous, and 13 are homozygous recessive. Determine the allele frequencies of *B* and *b*. (3 marks)

$$p^2 + 2pq + q^2 = 1$$

$$BB = 443/600 = 0.74$$

$$Bb = 144/600 = 0.24$$

$$bb = 13/600 = 0.02$$

$$p^2 = 0.74 \quad p = 0.86$$

$$2pq = 0.24$$

$$q^2 = 0.02 \quad q = 0.14$$

Allele frequency of *B* = 0.86, and *b* = 0.14

Appendix G

Peer-Led Team Learning Questionnaire

Circle one for each of the following statements.

- 1) I felt comfortable discussing questions relating to the class topic with my peers in small groups. (1–strongly disagree, 2–disagree, 3–unsure, 4–agree, 5–strongly agree)

1 2 3 4 5

- 2) I felt the discussions in small groups helped me to gain a better understanding of the topic. (1–strongly disagree, 2–disagree, 3–unsure, 4–agree, 5–strongly agree)

1 2 3 4 5

- 3) I would like to see more small group learning sessions take place in class. (1–strongly disagree, 2–disagree, 3–unsure, 4–agree, 5–strongly agree)

1 2 3 4 5

- 4) I think having small group learning sessions prior to the final quiz helped me to answer questions on the final quiz. (1–strongly disagree, 2–disagree, 3–unsure, 4–agree, 5–strongly agree)

1 2 3 4 5

- 5) I think I felt more confident explaining the topics we discussed in small groups to someone else after the session. (1–strongly disagree, 2–disagree, 3–unsure, 4–agree, 5–strongly agree)

1 2 3 4 5

- 6) Overall, how would you rate your experience of the sessions? (1–very negative, 2–negative, 3–neutral, 4–positive, 5–very positive)

1 2 3 4 5

Appendix H

Interview Questions

1. How did you feel about the peer-led teaching sessions?
2. Would like to see more of these sessions implemented? If so, why? If not, why?
3. Did you learn or gain from these sessions? If so, what? If not, why?
4. Are the peer-led teaching sessions different from regular classroom teaching? If so, how? If not, why?

Appendix I
Observation Protocol

Date: Session:	Students engagement in peer-led sessions as evidenced by levels of participation	Other

Appendix J

Example Questions Peer-Led Team Learning Sessions

Example Questions for PLTL sessions – note only every other session will have PLTL sessions (more than likely the * sub – topics)

History of Evolution—conversations

1. What is evolution?
2. How does evolution affect our daily lives?
3. Give examples of how you see evolution working in our environment?
4. Why is it important to study evolution?

***Natural Selection**—conversations

1. Explain Darwin's theory of Natural Selection.
2. Describe how an organism's ability to adapt affects its ability to survive.
3. What role does genetics play in Natural Selection? Explain.
4. How does Natural Selection affect organisms in today's environment (i.e., in terms of global warming—environmental changes)?

Patterns of Selection—conversations

1. How does selection account for mutations that occur that can be beneficial (e.g., sickle-cell anemia)?
2. Why are some phenotypes more favoured than others depending on the environment that organism inhabits?
3. What role does selection play on evolution of complex structures?
4. How does sexual selection affect the gene pool of organisms (i.e., mating success)?

***Speciation**—conversations

1. What is speciation?
2. What events can occur that would lead to the formation of an entirely new species?
3. Describe the mechanism put into place to prevent fertilization between species.
4. Why are there specific mechanisms to inhibit the interbreeding of species?